UNIVERSITY OF BIRMINGHAM

INTRODUCTION TO HCI

Designing a New Heating Control System

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Contents

1: Introduction

Human Computer Interaction (HCI) is becoming more important everyday as computer systems become more integrated into everyday life. It is often an overlooked aspect of programming or system architecture that can have significant impact on how a system is used by the majority of users.

Predicting how users will interact with a program or an interface can be difficult because it is unlikely that all users will react in the same manner posed with the same questions. It is for these reasons that HCI is important; it is the link between the user groups and the system creators. Well-implemented HCI processes can save significant investments in time and money by ensuring that the system is properly planned and tested to avoid a scenario where a system is delivered and no consideration has been made for how the users will interact with it.

Methods such as prototyping and the use of personas to evaluate the potential products can identify problems early on in the design process. This is vital to avoid spending too much time and money on a product that ultimately has flaws its design.

This report will include a number of methods to show how even in the simplest of cases good implementation of HCI methodology can identify problems in a product and help remove these before a final design is created.

The aim of the project was to create a design process for a computer based system. There are many systems that people use on a daily basis that are poorly designed and it is the aim of this project to identify one of these and attempt to create a number of prototypes to try and improve the interface between the system and the person interacting with it.

2: Definition of Problem

The system chosen by this team was a central heating control unit, it was commented on from various members within the group that they had encountered many different types of control unit in houses they had stayed or lived in, and often very few of them had been simple to use. It is often the case that the system is used in its most basic form, to either turn the heating on or off. Or it is used minimally - for example, the system will be set once when the person or family move into a property and then left, not taking into account changing needs for the people that live in the property.

2.1: Project Goal

The goal of the project is to create a control panel that makes it simple for a person to make changes to the way the property they are in is heated, but also to give the flexibility to how different people may use it. The panel should offer an easy to read display, a clear indication of current conditions within the property and an easy method to adjust the settings.

3: A Review of Heating Control Systems

It is important when considering a new type of control unit to consider what people are used to dealing with. The following section will focus on the different types of heating control unit that have existed in the past, those that currently are being implemented in properties, and possible future implementations. There will also be consideration made of the difference between systems that heat individual homes and those expected to control larger buildings such as office blocks.

3.1: Studies of Heating Control Unit Usage

In a study done by Wilhite et al (1996) it was discovered that more than 50% of households in the city of Oslo failed to adjust their control systems at night and 28% of households made no change for when they went on holiday. These high numbers would indicate a significant problem with users interacting with their control systems at all even if it were to make infrequent changes for example when they were to go on holiday.

This lack of knowledge in how to use the controls, or at least lack of confidence in the control system is reflected in the study done by Meier (2012). Here they carried out a number of studies into how people use their control systems and found that people frequently claimed they “didn’t know how to use it” or “didn’t want to mess it up”, indicating a lack of confidence in their ability to use the technology. The studies also showed a significant 89% percent of respondents to an online survey claimed they rarely or never adjusted the controls.

3.2: Typical older types of heating control systems

Historically, heating control systems have been fairly basic in their design. Regardless of this, however, many people struggle to use them. Peffer et al (2011) suggested that only 56% of home owners in America always programmed their heating control unit. This project is designed to try and increase usage of a building's heating control system through the use of a better designed interface.

Previously, heating control systems have been split into two areas, the older, ‘manual setting’ type of heating control unit that requires regular direct input from the user, and the more modern approach of a programmable heating control unit that can vary its settings dependent on how the user initially sets up the various modes.

Manual systems typically looked something like the one found in fig. 1 below:

Fig 1. Pin type control unit. (www.cse.org.uk)

These types of systems varied in sophistication, however the general theory behind using them was to set the pins, in the case above the blue and red arrows, to the times of day the user wanted the system to turn on and off. They often also offered some limited programs such as heating all day or for a set period, for example 12 hours or all day (and not night time).

These systems were basic at best and have some significant problems; firstly they often only had one set of pins meaning that only one setting for when the heating turned off and on was available. This is very inflexible as typically most homes are used differently in the week to how they are used at the weekend, meaning that the system would have to be changed on a very regular basis.

Secondly, the dial which indicates the time of day to which the pins are set was often very small, this meant reading the numbers displayed on the dial was difficult. These systems also lacked the basic ability to consider daylight savings adjustments, so they would not respond differently after the adjustments to the clocks were made.

These types of control system have however begun to be replaced by more advanced panel type arrangements with digital displays as found in fig 2 below.

Fig 2 digital type control unit. (www.cse.org.uk)

These newer types of control improve on the previous pin design by typically allowing multiple programs to be set so the heating system can react to different days of the week and different times of day. They do however pose problems of their own, the model pictured above is a fairly simple design, however some control units have a significant number of buttons that may appear to make the unit more complicated to people, and therefore may use the unit even less. There is also little change in the size of fonts used on the unit meaning that people with even slightly impaired vision may struggle to read what the buttons do.

3.3: Current Heating Control Units

The Heatmiser range:

There are several models (with varying degrees of complexity/functionality) but all seem to be variations on the same basic design. Below is an overview of the most expensive non-wifi model currently available on their website:

Fig 3: Heatmiser Touchscreen Thermostat (http://www.heatmisershop.co.uk/room-thermostats-c1/touchscreen-thermostats-c9)

Model: PRT2-NTS
Size: 110 x 100 x 17mm

Features:

- Blue backlight
- Ability to select between Celsius or Fahrenheit
- Adjustable frost protection (a minimum temperature you can set, to e.g. stop pipes freezing)
- Programmable, with weekday/weekend or 7-day options
- Holiday function (allows you to set a reduced temperature for a number of days, for when you are away for a prolonged period)
- Hold function (keeps the temperature constant for a chosen number of hours)
- Programmable for two zones (i.e. you can adjust the settings individually for two different areas of the house)

Pros and cons of Heatmiser touchscreen models based on user reviews:

Pros:

- "Screen" option freezes screen for 15 seconds, allowing it to be cleaned
- Displays actual room temperature (unlike traditional analogue controls)

Cons:

- The backlight doesn't come on until an icon is touched; this can make it difficult to see what one is doing
- Method for setting the time is somewhat unintuitive
- Can be easy to press the wrong button - though this may be due to screen quality rather than size and/or layout
- Smallest increment for adjusting temperature is 1 degree, which some users find is too large
- Target temperature is not displayed alongside actual temperature.

ecobee Smart Thermostat:

Fig 4: ecobee Smart Thermostat (http://www.automatedhome.co.uk/new-products/ecobee-launch-wi-fi-smart-thermostat.html)

Size: 5.5 x 3.2 x 1 in (approx. 140 x 80 x 25 mm)

Features:

- Full colour display
- Displays outside temperature
- Programmable
- Can switch between Celsius and Fahrenheit
- Generates statistics

Pros and cons based on user reviews:

Pros:

- Easy to program; interface is easy to understand

Cons:

- Temperature is set using a slider on the touchscreen, which can make it difficult to choose the temperature accurately
- Interface is too small

Honeywell evohome;

Fig 5: Honeywell Evohome (http://www.pocket-lint.com/news/124619-honeywell-evohome-control-individual-radiators-with-your-phone/gallery#photo-3)

Features:

- Full colour screen
- Several rooms can be controlled individually.
- "Quick options" button on the home page; this leads to a page with options such as an "Economy" mode, which reduces the temperature in all rooms
- Includes a fault logbook
- 0.5 degree (Celsius) increments
- You can make heating schedules for each room; ability to switch between day and week views

There currently do not seem to be any user reviews, most likely because it is a very new model. It is arguably the most attractive model out of the three, and based on the simulation provided on the company's website, it seems quite easy to understand and use. If there were to be criticism, it would be the lack of a "help" button on the homepage (the same could be said for the other examples above); if someone is unsure of how to do something, it would be much easier for them to have an easily accessible help menu, rather than having to dig through various menus and options in the hopes they will come across an answer somewhere. Since paper manuals often get misplaced, having a manual available from the touchscreen would be useful. That being said, a good interface should be more-or-less self-explanatory.

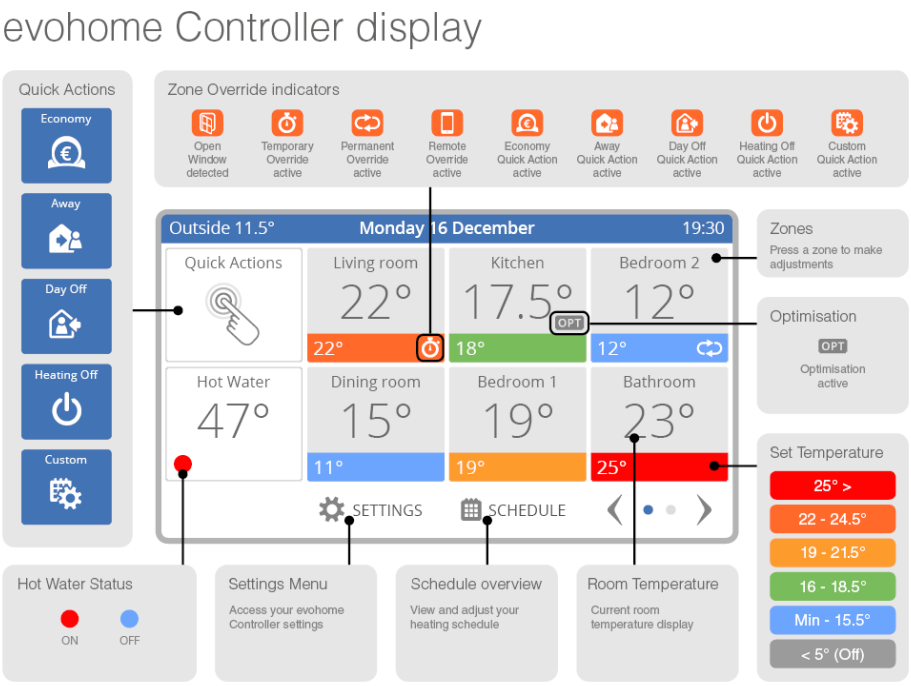


Fig 6: "FAQs" - "How does the evohome controller work?" (http://www.evohome.info/#howItWorksDiagram)

3.4: Future Heating Control Units

NEST

"The Nest Learning Thermostat was made for the other 90% of us who rarely or never program our thermostats. Instead of needing to be programmed, Nest learns from you." - Yoki Matsuoka, nest.com/blog.

Fig 7: The NEST Thermostat (http://www.technobuffalo.com/tag/nest/)

Nest is a new company aiming to introduce the latest technology into the home to both improve the ease at which we can control our environment and save money.

The Nest thermometer is a thermostat and control system, however the control system is somewhat hidden from the users view. There is a thermometer inside the unit that feeds back to allow the system to either increase or decrease the temperature of the room. The nest thermometer has the ability to learn a families habit of heating so that eventually the thermostat and heating never needs to be altered or changed.

Nest thermostats can be placed in up to 10 different rooms that accurately monitor and control the temperatures across the house. The nest syncs with a broad spectrum of other sensory devices to provide a holistic and truly adaptable and automated system. Sensors such as humidity and motion can be added to allow extra functionality in a pseudo modular system.

The humidity sensor constantly checks the humidity both inside and outside and can feedback to any attached humidifiers or dehumidifiers. The motion sensors ensure that only rooms being used are actually heated and that if the house is empty i.e. during school/work, or whilst on holiday, that no energy is wasted. The Nest thermometer also has WI-FI connectivity that allows it to sync with the local weather and adjusts the internal temperature accordingly (TechnoBuffalo).

E.on Smart meters

Although not truly a heating system control unit it gives great insight into the heat and energy used in the home and an overview of the heating situation.

Fig 8 E-On Smart Meters (https://www.eonenergy.com/for-your-home/saving-energy/smart-meters/how-smart-are-smart-meters)

Although it does not control the temperature of the home smart meters show an accurate and immediate usage figure allowing you to monitor the energy consumption and efficiency of your home and heating routine (E-On).

3.5: Commercial Heating Control Systems

Commercial heating systems differ from domestic systems, as they cover a greater area, often with numerous boilers and heating systems linked together. The challenge

therefore is to provide a control system that gives the user an overview of, and functionality to modify the conditions in multiple zones, from a central control point, as well as the individual areas. The Carbon Trust recommend 'zoning' when appropriate, as it provides closer control over temperatures, and more efficient heating – saving both money and resources (Carbon Trust, 2011). Here, current systems from two companies that implement zoning are examined and critiqued.

Vaillant Cascade Controls

VRC 630 Boiler Management Control.

The VRC 630 is a 'weather compensated cascade control' – as well as a time-dependent programme for heating and hot water supplies, it also connects to outdoor sensors, which result in a weather-dependent operation. The control system may control up to two systems – or with additional mixer circuits, up to 15, however all circuits are controlled by the central control if a remote control is not also installed (see below).

All settings are adjusted and monitored by the central control. There is a graphic display, with plain text used, which is an advantage – new users don't have to learn an array of symbols in order to be able to control the system. Another advantage of the system is multi-lingual support.

The control display is of a variable nature; the different levels of menu may be accessed using the dial marked '5' in Fig 9. The current menu is represented numerically in the top right corner of the screen, and also by name on the top right. Having the menu names displayed in this way is useful once a user knows the order of the menus, but some guesswork will be required by new users, who may have to scroll through completely before they are able to remember which menu option comes when. The information required is therefore not immediately attainable.

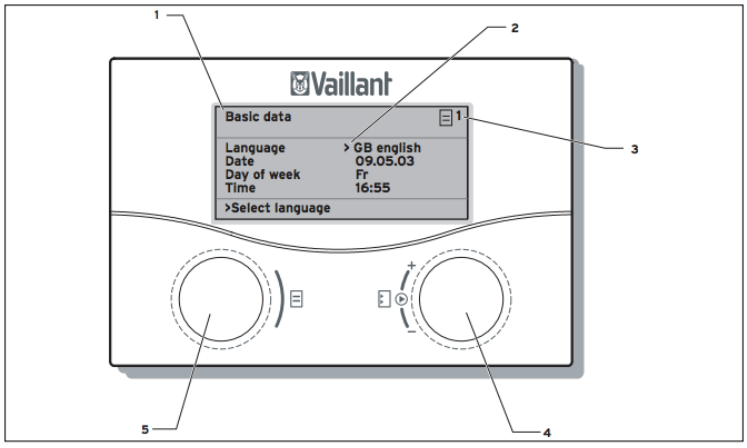


Fig 9: The operating overview of the Vaillant VRC 630. Key: 1 – Menu Name. 2 – Cursor indicating selected parameter. 3 – Menu number. 4 – Dial: Set parameter (turn), select parameter (press). 5 – Dial: Select menu (turn), Activate special function (press).

The most-often used display of the system is the 'basic display' (Fig. 10), which displays the current operating statuses and target room temperatures of each

individual heating circuit. 'Operating modes' can also be seen and adjusted – these include 'Eco' and 'Auto'. Date, time, and outdoor temperature are also displayed. As the circuit adjusts itself based on the outside temperature, it may be useful to have this displayed, as the user can then be aware of how much extra work the system is performing in order to heat to the target temperatures.

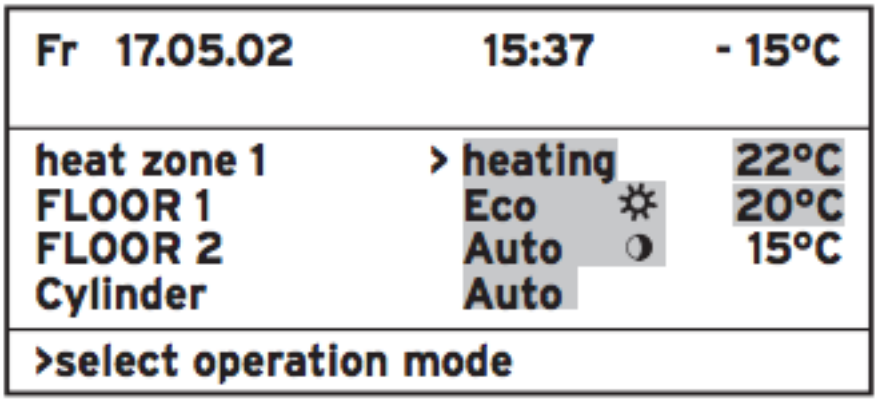


Fig 10: The 'basic menu' screen of the Vaillant VRC 630

Further menu screens for each heating circuit can be accessed by first highlighting the required circuit by pressing the right hand dial until the circuit is displayed, and then turning the dial can change the parameters. This method of highlighting and altering parameters seems rather clunky – as the turning motion is used on the opposite dial to scroll through menus, users may then use this motion to try and scroll through parameters. This would result in confusion, and reading of the manual may be necessary to realise that pushing the dial is the required motion.

There is a further 'code level' section, which displays engineer-level parameters. These may be viewed, but not changed, by the user unless a password is entered. Having these displayable to the user may add confusion to the parameter setting process – it may be better to have the whole section protected by password before the user is able to be confused by these extra parameters.

A further disadvantage with the 'basic' menu is the fact that only four 'zones' are viewable on the screen at any one time. Many more may be controlled by the system, so fall 'beyond the fold' of the bottom of the screen. They are not listed alphabetically, so with a large number of systems in place, the only option users have is scrolling through the whole list until they reach their required system. This may be combatted through a larger screen size, or even alphabetising the results would increase the usability of the menu.

(Vaillant, 2013a)

VR80 Room/Zone Control

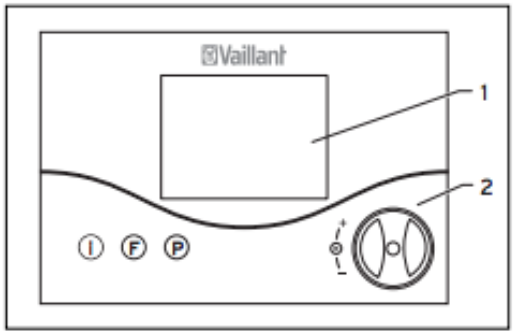


Fig 11: Device overview. Key: 1- Display. 2– Dial (turn / click). I- Info button.
F- Special functions button.
P- Programming button.

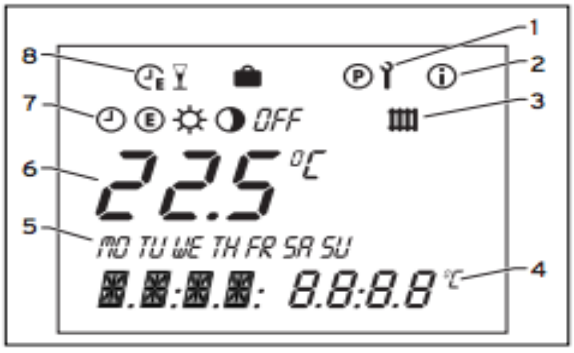


Fig 12: Display overview. Key: 1 – Diagnostics. 2 – Info level. 3 – Heating circuit symbol. 4 – Time & Temperature display. 5 – Days of week. 6 – Actual Temperature.7 – Operating Modes. 8 – Special Function.

The VR80 is a 'bus modular ' remote controller intended for use with the VRC 630. It controls one of the sub-systems that may be connected to the VRC 630. Whilst all changes that can be made with the VR80 may be made with the VRC 630, the VR80 can be located within the zone that it affects, meaning that in larger commercial spaces, it is easier for users based within that zone to make changes to the heating system (that only affect that zone – everywhere else is still in the domain of the VRC 630, or another remote controller located within another particular zone). The 'turn and click' operation also used in the VRC 630 is again used here, which helps users familiar with one device to be able to use its sister device without too much learning.

Turning the dial causes the actual temperature to disappear from the display ('6' on Fig 11), and the required room temperature appears at '4' on Fig 12. After a 1 second pause, the user can then turn the dial to make changes to the required room temperature. After five seconds of non-operation, the display then returns to its normal mode. The novice user may have some issues with this functionality. They might not understand why there are two separate temperature displays – and as the main temperature disappears when the dial is turned, and there is a delay between turning the dial and being given the ability to change the temperature, they may not realise that they have accessed this function. Also, as the new desired temperature disappears from view after five seconds, with the display returning to the current temperature, they may not realise that they have completed the process. Some form of confirmation that the desired temperature has been altered may be helpful here.

One of the advantages of the VRC 630 was that plain text was used rather than operating symbols, which allowed all users to understand the information displayed without having to consult a manual. The VR80 has replaced this text with operating symbols ('3' and '7' on Fig 12.), which undermines this feature that made the VRC 630 easy to operate. Furthermore, there is wasted space on the display, as all of the days of the week are constantly present, with the current one highlighted. This is a drawback of the display technology used, but a more dynamic LCD option would add significant cost to the product. (Vaillant, 2013b)

VR90 Room/Zone Control

The VR90 is a second option available to perform the same function as the VR80 – a remote control device for use with the VRC 630 for the control of one zone.

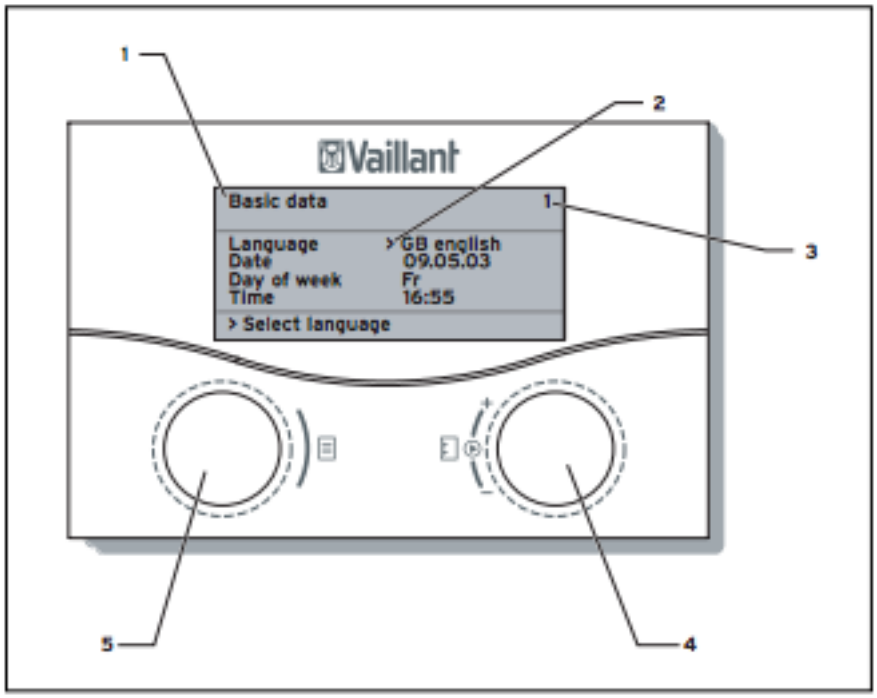


Fig 13: The operating overview of the VR90 zone control system. Key: 1 – Menu name. 2- Cursor indicating selected parameter. 3 – Menu number. 4 – Dial: Set parameter (turn), select parameter (press). 5 – Dial: Select menu (turn), activate special function (press).

The VR90 is an improvement on the VR80 in a number of ways – the controls are identical to those of the VRC 630, which allows for a fluid user experience between the two devices. The operation is also very similar, the plain text information display is back, doing away with the confusing pictorial representations of the VR80. The menu system is similar to the VRC 630, and the basic display is almost identical – but only displays the information relevant to the zone it occupies (see Fig 8). As such, it shares most of the advantages and disadvantages of the VRC 630.

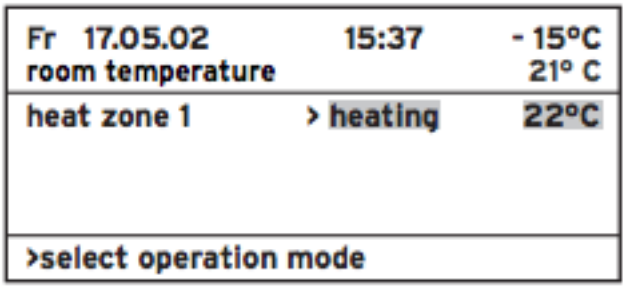


Fig 14: The 'basic menu' screen of the Vaillant VR90.

(Vaillant, 2013c)

Johnson Commercial Comfort

Johnson offers a range of 'commercial comfort' systems, as part of an integrated suite of 'holistic' HVAC (Heating, Ventilation and Air Conditioning) products. The system comprises of a system manager and zone co-ordinator, providing the comparable functions of the VRC 630 and VR80/90 mentioned above, as well as zone sensors, bypass controllers, and I/O modules. This review will focus only on the system manager and zone controllers, as they are the elements of the system that require user interaction, through a colour touch-screen interface, which is billed as 'intuitive' (Johnson Controls, 2011).

The System Manager and Zone Controllers are LCD touch screens, that use a one-touch gesture in order to make all selections, using the finger rather than a stylus or pen. The interface is menu driven, which allows the user to set system parameters, access system information, and monitor and control connected equipment. Operations are carried out through one of five screens (Fig 14), 'Home', 'Alarm', 'Summary', 'Schedule' and 'Setup'. The active screen is indicated by its menu icon turning green. This interface is easier to navigate than the VRC 630's, as all menus are constantly displayed at the top of the screen, however the reliance on an icon based navigation without any text requires the user to already know the meaning of the icon, or select that screen to see its title once it has loaded. This is a drawback of the system.

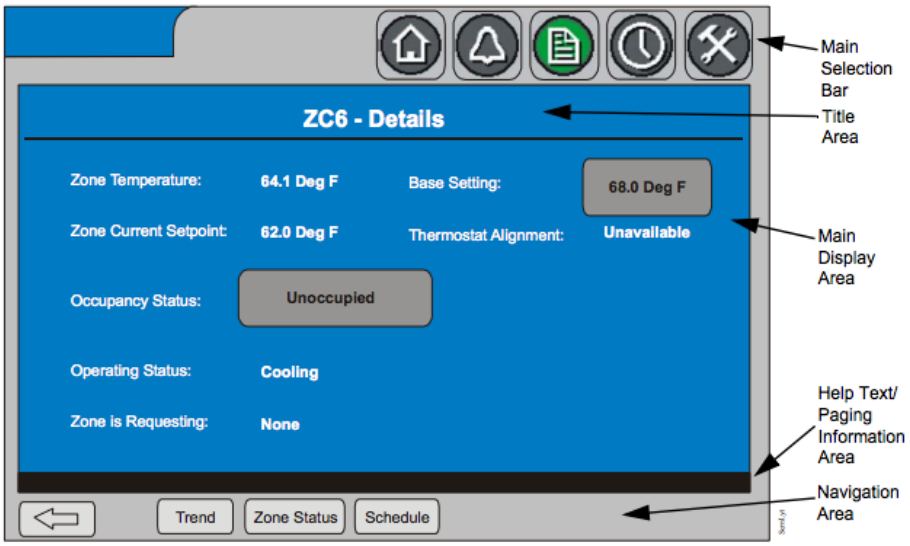


Fig 14: The basic screen layout of Johnson's System Manager.

The black bar at the bottom of the main display area provides optional help text, as well as page numbers if more than one page of information is being displayed. This is a useful feature, which may be an advantage for novice users, as rather than consulting a manual, they are provided with relevant help when the need for it arises. It could be argued that the fact that help text is necessary at all is indicative of a poorly designed system, but if some controls are specific to HVAC software, it may become necessary to include terminology that the layman cannot understand without this help text.

An advantage of Johnson's system is the matching UI between the system manager and zone controller – once a user has mastered one, they have by default mastered the other. The similarity can be seen in Fig 15:

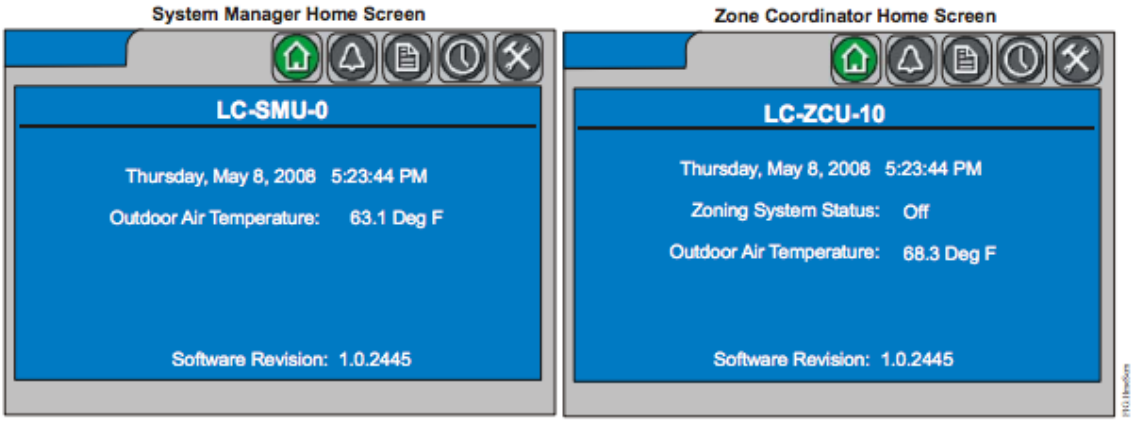


Fig 15: The home screens of the System Manager and the Zone Coordinator.

One possible disadvantage of the system, that has been addressed, may have been the fact that the UI is based on an LCD screen, that is more power-intensive than a traditional, dial based control system. This is not an issue with the system, however, as after 10 minutes of inactivity, the UI times out, logging out the user, and after a further 5 minutes, the screen turns blank.

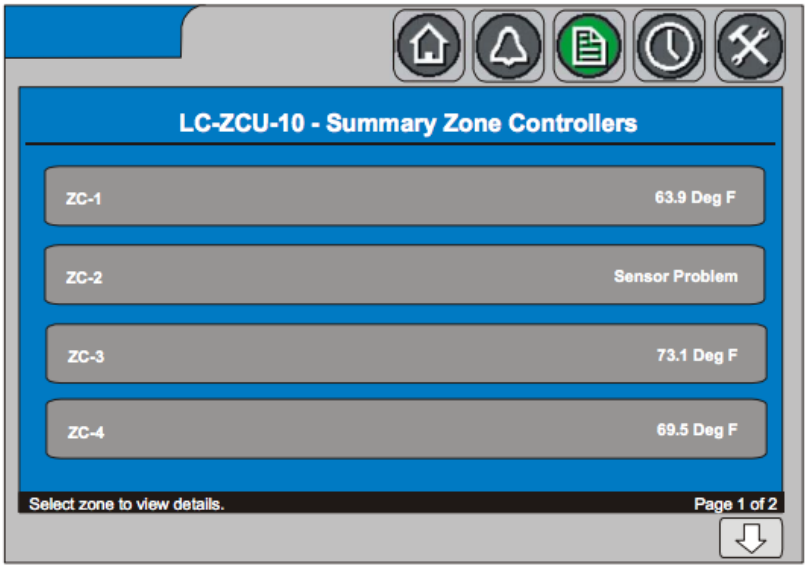


Fig 16: Zone controllers summary page on the System Manager.

Fig 16 shows the summary page, with the information on each zone, available from the 'Summary' page accessed via the navigation bar. Each of the buttons visible in Figure 9 lead through to a full summary of information for that particular zone. This page suffers from the same issue as the VRC 630, in that only 4 zones are visible at once, and the user must scroll through pages of information to find the zone that they are interested in (although here the results are alphabetical, which is helpful). There is a lot of wasted space resulting from the buttons being stacked one-by-one vertically – at least nine would fit onto this screen without any loss of information.

The system also contains the functionality for alarms to be sent to different devices, as well as being displayed on the system manager and zone controller, in the case of an unexpected event. These alarms can be configured to be sent to pagers, email accounts, and as text messages, which is a useful service, that could ensure that problems are dealt with more quickly that the alarm only being raised internally. Similarly, the UI is accessible via a web browser, which means that issues that are fixable purely through the UI are remotely fixable.

A useful screen that can be accessed through the zone summary page is a 'Trend Summary Screen' (see Fig 17). This allows the user to view the recorded temperature of a zone at 15 minute intervals, which is useful in identifying temperature patterns and anomalies. This screen however only displays the information in a textual format. A clearer picture would be given through a graphical representation.

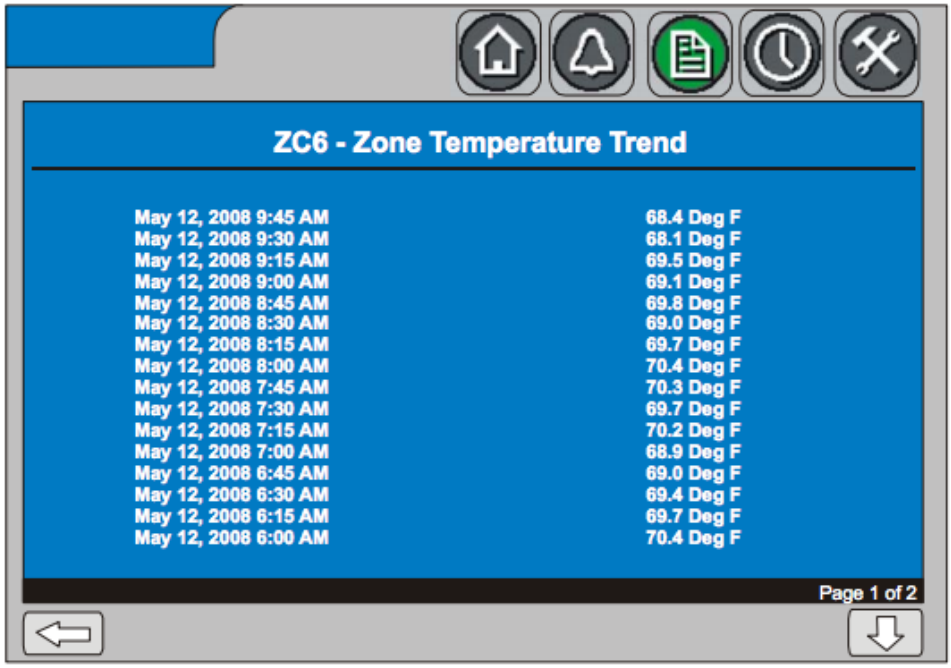


Fig 17: The trend summary screen

(Johnson Controls, 2008)

4: Analysis of User Requirements

User requirements are vital to the design of a successful product. It is important to try and identify as many of these requirements as early in the design process as possible. In order to do this 4 varied personas have been created in order to identify user requirements each with their own individual goals and problems with current systems. They will then be used to summarize the main points to be carried into the design of the initial prototypes.

Building Manager

Name - Oliver Smith
Age – 37
Occupation – Experienced Building Manager

Current interaction: HIGH
Wanted interaction: MEDIUM
Technological ability: HIGH

Description

Oliver is the building manager at the Barrack Street office for Warwickshire County Council. He is responsible for ensuring that the building operates normally and that it is possible for people to work in a comfortable environment all year round. Some of his specific roles include; ensuring adequate maintenance is carried out, the building is secure and that the building is heated correctly.

He works typical office hours of 9am to 5pm, with some flexibility over when he starts and finishes. However, as part of his role of being in charge of the building it often means that he has to come in early or late to ensure everything is operating smoothly for the work force that use the building.

The building he is responsible for is a fairly large 4-story building that houses approximately 200 people on a daily basis. The office is not open at the weekends. The Health and Safety Executive states that the building must be at least 16 degrees Celsius for people to work in, therefore Oliver must ensure the building is at minimum this temperature for office hours. He typical keeps the heating systems at a steady constant to cater for this, however this changes around holiday periods where the heating is turned off. This means that when people return to work the heating needs to be adjusted to ensure the building is back at least 16 degrees Celsius.

Main Points

- Oliver is comfortable with most of technology that is typically found in the office.
- Oliver is experienced in his role and has seen various different types of heating systems at the buildings he has previously worked at.

- Oliver is very aware of the tightening budget constraints on things like building management, and is aware that he may be asked to alter the way the building is heated.

Pain points

- The building he is in charge of is fairly old and loses heat very easily in different areas, meaning that achieving a consistent temperature is difficult.
- It is not possible for the control system to have multiple programs for different holiday periods, meaning he has to reprogram it every time.
- There is no way to operate the controls other than being in the building, meaning he often has to start early and leave late.

Goals

- To have a flexible system that allows different areas to be heated independently.
- To save money on heating bills
- To be able to operate the system remotely.
- To have set programs for different times of the year.

Scenarios

- It is the first day back after the Christmas break and Oliver has got to work at 5am to ensure the heating system is turned back on and the building is starting to heat back up again. The building is slowly heating up however it is obvious that the top floor is not going to be warm enough by the time people are due to start, he therefore decides to increase the temperature output for the whole building in order to heat the floor quicker. He knows this will not be popular with his boss however he sees little alternative.

- It is a typical winters day in the office and people are complaining on the top floor that the office is too cold. Oliver is aware that building work is on going on the roof at the moment and this means that more heat is being lost from the building than usual. He checks the temperature in the area via the thermometer he has and it shows that the temperature is close to the minimum but acceptable. He then sends an email out to confirm that the temperature in the office is acceptable. He wished that there was some kind of visual aid for people in the office to see the exact temperature in the area.

- It is Friday afternoon and the last of the office workers have left, Oliver starts his routine of turning off the heating system manually. He wished that this process could be automated meaning he could leave the office earlier.

Parent/family woman

Name - Susanne Harrison
Age - 42
Occupation: - Housewife, part-time freelancer

Current interaction: MEDIUM
Wanted interaction: MEDIUM
Technological ability: MEDIUM

Description

Susanne is married, with a 14-year-old daughter and a 3-year-old son. Her husband works full time, with a typical 9-to-5, Monday-to-Friday job. Her daughter is in school weekdays from 9 to 3. Her son is in nursery on Mondays, Wednesdays and Fridays, from 10 to 2. While her son is in nursery, Susanne works from home as a freelance proofreader. On Tuesdays and Thursdays, Susanne is often out with her son, taking him to the park, to meetings with friends, or out shopping with her.

The weekend schedule frequently changes from one week to the next: some or all of the family may stay at home for much of the day, or they may all have a day's outing, or be out for the whole weekend visiting relatives, for example.

Main points

- The family is not on a particularly tight budget, but Susanne and her husband have noticed that heating costs contribute too much of their energy bill, and would like it if they were able to be more economical with their heating.

- Susanne is reasonably experienced with computers, using her PC on a daily basis; her job is web-based.

- She owns an iPhone, so has some experience using touchscreen technology, but admits she has not explored much of the phone's available functionality, having felt neither the need nor the inclination to do so.

- She is otherwise not a very technically-minded person; she sometimes half-jokingly refers to herself as a "techno-peasant", and frequently employs her daughter to e.g. help her with the printer/scanner.

Pain points

- Often pressed for time
- Has little patience for figuring out how something works
- Will sometimes forget to turn the heating off once she has turned it on

Goals

- To have programmable heating controls that are quick and easy to get to grips with, and flexible enough for her and her family's busy and sometimes inconsistent schedule(s)
- For the controls to be child-proof (so her son cannot play with them), but easy for her teenage daughter to use (since she may want to ask her daughter to turn on the heating, etc.)
- To save money on heating, if possible

Scenarios

- On weekdays, Susanne's husband gets up at 7:00 (he has to be out of the house by 8:00); Susanne gets up at 7:30 at the latest. Nobody likes getting up when it's cold, least of all Susanne's teenage daughter, who is reluctant to get out of bed at the best of times. Susanne would like the heating to come on at least half-an-hour before her husband wakes up, and for it to not turn off until 8:00, by which time everyone is (usually) up and dressed. Susanne wants the heating to come on later on weekend mornings, as it is normal for everyone to sleep in.

- Susanne does not like working in a cold room, since it is hard to type with numb fingers; she would like the heating to come on before she gets back from dropping her son off at nursery so she can start work in comfort and therefore be more productive. She would also like the heating to only come on in the room she is working in, since it is a waste to heat unoccupied rooms.

- School and nursery have broken up for the Christmas holidays. Susanne needs to change the heating's weekday schedule to account for this, but seeing as it is a short-lived state of affairs, she would like to be able to save the normal weekday schedule, so she can switch back to it easily once the holidays are over.

Elderly, retired gentleman

Name - Humphrey Oldman
Age - 81
Occupation - Retired country club green keeper.

Current interaction: MEDIUM
Wanted interaction: LOW
Technological ability: LOW

Description

Humphrey lives in a bungalow in a suburban town with his wife of 55 years, Margery (aged 79). Their days are spent mostly together, in a fairly solid routine. They have two sons and two daughters, each with multiple grandchildren, who usually visit weekly. Humphrey acquired a decent amount of money over his career, as did Margery, which is supplemented by their pensions. The couple are usually awake by 6am independent of whether it is the weekend, and spend their day either entertaining grandchildren, or getting the bus into town to eat in the local cafés.

Both Humphrey and Margery are beginning to lose sight and aural functions, and have to rely somewhat on walking sticks for mobility.

Main points

- Although the couple acquired a decent amount of wealth, Humphrey is still conscious of not overspending on heating unnecessarily, by leaving it on while they are out for example.

- Neither Humphrey or Margery are technically competent – there is no computer in the house, and although they have a premium satellite TV package, they never use the advanced features for fear of doing something wrong.

- Any information conveyed by small text or symbols isn't viewable by Humphrey, due to his poor eyesight. Margery's is slightly better, and she can sometimes be of help.

- Humphrey does require the heating to be active at most points during the day, unless the weather is agreeable or he is out of the house. If the house is too cold, he is at risk, as his body is becoming weaker.

Pain points

- Humphrey can't use a user interface of any real difficulty without being shown multiple times, over several occasions. Even then, he still often gets confused, and gives up the task.

- Small buttons and menu options are difficult for Humphrey to see, or be able to press thanks to reduced control over small motions.

- Although he wants to not use heating when he is out of the house, he often forgets to switch it off before he is either out, when it is too late, or when he is in a different part of the house to the thermostat, when it is a lot of excess effort.

Goals

- To have a simple user interface with no confusing options or menus, to be able to change the temperature, or turn the heating on or off.

- To keep the house at an optimum temperature – when they arrive back from a trip into town, the house should not be cold for long. This could be achieved using an (easy to set) timer on the control system.
- To be able to remember (or instantly recognise) how to use the control system without having to rely on help from others.

Scenarios

- Humphrey and Margery's grandchildren are coming to visit. They have their heating on high in order to keep themselves warm, but once the house is full and the children are playing the heat is beginning to become too much. They need to turn the heat down.

- Humphrey and Margery are about to leave the house to spend a couple of hours in one of the town's cafés. They want to turn the heating off, but for it to come back on before they arrive back to the house, so the house is warm for them to come in to.

- It is 3:30 AM, and Humphrey wakes up, the house is not warm enough for him to be comfortable. He needs to use the thermostat in reduced lighting in order to bring the temperature back up to an acceptable level.

Single occupant / Young professional

Name – Dan Cole
Age - 25
Profession - Junior Trader at Oil.Co

Current interaction: HIGH
Wanted interaction: LOW
Technological ability: HIGH

Description

Dan is a junior trader at a futures trading company based in canary wharf, London. Although the wage is good he is still young and having to live in London so is very conscious about the cost of living and bills. Dan's flat is small but gets very cold in the mornings, at the moment the heating system in place is confusing and currently Dan has been unable to automate or program is despite several attempts, including downloading the instructions from the internet.

On several occasions Dan has returned from work to his home very warm, indicating that heating system has been on, heating an empty home, costing him money. Dan is familiar with new technology and finds it more intuitive and easier to use than some older "technologies", which is part of his frustration with the current thermostat/heating system.

Pain Points

- Dan finds there are too many buttons coupled with tiny writing.
- Dan finds his current system very slow and unintuitive to program, the + & - buttons are inaccurate and fiddly to use.
- No precise temperature control, just a dial for hotter or cooler.
- Dan cannot program weekends differently to week days.
- If Dan turns the heating on ad-hoc he sometimes forgets it's on, costing him money, remaining on, there is also no timer function for a boost of heat.

- Dan is never sure of which button to press at any time as there are too many and they often double up on features.

Goals

- To be able to program the heating properly for his needs.
- To be able to change the weekly program easily especially as winter moves to summer.
- To save money on my bills.
- To be able to set a precise temperature and leave it at that temperature.
- To have some new connectivity between heating and his smart phone so it knows if he is home.

Scenarios

- Dan needs the heating to be programmed to come on at 5:30 in the morning as he is up early before the markets open, but only for a short time.
- Dan needs to be able to turn the heating on ad-hoc, he gets in late depending on market performance and research that needs to be done, so he does not arrive home at a regular time and not until it is late.
- At the weekends Dan likes to sleep in so he wants the heating to come on later at the weekends but still for only a short time, also he still needs the ad-hoc function to be available to dry his laundry.

Summary

This section has laid out 4 different personas that have various wants, needs, and problems. Below is a list of the general points that were raised by the personas that the first prototypes should attempt to address:

- The system should offer flexibility for users between being able to have presets, timings or constant heating options.
- The display should be very simple and clear, with the ability to use more options if the user desires it.
- To be precise with heating options to help save money.
- To have an obvious display of the current conditions in the house.

It should be noted at this point it was clear that the personas wanted some significantly different options from the prototypes. It was therefore decided at this point that the focus of the prototypes would be on individual home systems rather than larger industrial units. Therefore the Oliver Smith persona became less important for initial prototype design because it was clear that these designs would likely not meet many of his goals.

Despite this his persona will still be used for evaluation for the rest of the project to give an additional opinion on the evaluations.

5: Description and Rationale for first prototypes

5.1: Circular Design

Design features

- Few buttons on the face of the device, this results in a cleaner UI and is less daunting or intimidating, encouraging users to program the device.
- Outer bezel ring as a temperature adjustment is a familiar dial style approach so is intuitive to use by any user.
- Display is clear and relatively uncluttered allowing for easy viewing, this also helps to improve user confidence when programming the device.
- Difference heating schedules can be programmed for each day.

Rationale

The circular design is practical and feels immediately familiar and intuitive to use. The outer bezel moves like any other dial, and a 1hr only boost button is large and clear at the top of the device. The screen, while uncluttered, is small and clearly shows the basic information needed and what state the heating system is currently in. Setting the boiler to come on is simple, and the system is programmed in a small number of steps. The system can be programmed to have a unique routine for each day of the week, and once set the system requires little to no interaction.

5.2: Dial-and-buttons prototype

This prototype aimed to use existing, traditional temperature control design tropes and use them in manner that presented more information to the user more quickly. It takes a twistable knob for temperature setting, and allows the user to choose either continuous, timed, or preset settings, and use a long strip of push buttons in order to set times for the latter two. The rationale for this was that in using components that appear familiar on a boiler control in a way that may be more easily programmable, it would be less of a learning curve for people like Humphrey to move over to the system. Also with Humphrey in mind, audio feedback is given, which allows those that are short of sight to be able to hear what changes they have made.

Despite these good intentions, the desire to cling onto past technologies proved unsuccessful, as will become apparent. Replacing the button elements with a touch screen would have been hugely beneficial, as they actually hinders people like Humphrey by being trickier to use.

Strengths

- Provides clear visual and audible feedback on successful (or unsuccessful) attempts at using the functionality.
- Large, tactile, easy to use dial for configuring system in constant, timed, and preset modes.

- Allows for presets to be configured and used.
- Shows user graphically what the system will be doing over the day, and where in the process the system is.

Weaknesses

- No textual representation for mode selection or presets, relies on recall over recognition.
- Presets only last for 24 hours and require user to manually switch between them.
- Many, many buttons for setting of presets. They are small and difficult to use, and even then don't provide a fine enough structure for setting the system.
- Program buttons could be confused with change of mode buttons.
- How to set programs is not obvious.

Potential Improvements

- Have a text based labelling system rather than an icon based one.
- Move preset buttons to a location where they cannot be mistaken for the mode change slider.
- Redesign preset/timer setting system – introduce a more user friendly method of input, e.g. incorporate into the dial.
- Allow for presets to last for longer than 24 hours, or to be configured to initiate on a particular day.

5.3: Touchscreen prototype

Touchscreen technology has improved vastly in recent years, and many modern heating systems now make use of this technology. One of its major advantages is that it allows for a wide range of functions in a relatively small space; a variety of options can be spread across a number of "pages", with pages that are not in use being hidden; this makes it easier to design neat, minimalist interfaces. For these reasons, we decided to make one of the first generation prototypes a touchscreen model.

The touchscreen model was designed with Susanne Harrison's (the "family woman" persona's) requirements in mind. Details of the functionality are explained in the notes accompanying the prototype sketches, but below is a summary of the functionality that addresses Susanne's goals:

- Flexible and easy-to-understand programmable heating controls: The heating schedule can be adjusted for each day; schedules can be saved and loaded. (The prototype shows only two heating zones, but more zones could easily be added.)

- Child-proofing: This is not shown in the prototype sketches (since they only show "screenshots") but perhaps a slider/switch on the side or top of the body of the controls that one has to hold for a couple of seconds to lock/unlock the screen would work - it is simple enough for an adult or older child to use but a younger child may have difficulty tampering with it. A screen lock also allows the screen to be cleaned without pressing any buttons accidentally.

- Saving money: There is an economy option available under "Quick options". The user can also view a usage report under "General options", which includes an estimate of how much their heating is currently costing them.

6: Evaluation of first prototypes

The prototypes have been evaluated using Nielsen's heuristics:

1. Visibility of system status
2. Match between system and real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Minimalist design
9. Help error recovery
10. Help and documentation

The evaluation of each prototype consists of a list of positives, followed by a list of problems specific to each user persona. The severity of problems is marked on a scale of 0-5:

0 – a non-problem
1 – mainly cosmetic problem that is unlikely to occur often
2 – minor usability problem that is unlikely to occur often
3 – major problem that is unlikely to occur often
4 – major problem that is likely to occur frequently
5 – catastrophic problem; need to fix immediately

It should be noted that a 6 point scale was used for the evaluation, this is important because it was felt that if a 5 point system was implemented it would lead to often the middle option being chosen because the evaluator was not sure which one to pick. By assigning 6 options they have no 'middle ground' to fall back on.

6.1: Circular design

Positives:

	Heuristic
Large tactile dial makes temperature quick and easy to set.	Flexibility and efficiency of use Error prevention
Can be programmed for each day individually.	User control and

	freedom Flexibility and efficiency of use
Attractive, minimalist design.	Minimalist design
Back-lit display allows user to read the display in low light, and may help if they have weak eyesight.	Visibility of system status Error prevention
One-hour boost function provides a quick and easy way for user to temporarily override programmed settings if they are feeling cold.	User control and freedom Flexibility and efficiency of use
Few steps/button pushes needed to program the system.	Flexibility and efficiency of use Error prevention

Negatives:

Persona	Problem	Severity	Heuristic
Susanne Harrison	Heating can only be programmed to come on once a day.	4	User control and freedom Flexibility and efficiency of use
	How to program the heating is not immediately obvious without instructions.	2	Flexibility and efficiency of use Help and documentation
	Dial shows desired temperature, but actual temperature is not shown anywhere.	1	Match between system and real world
	Only one heating zone.	4	User control and freedom
	Method of programming the heating is not particularly efficient - no way of setting hours and minutes separately (which would speed things up), and Susanne has to press "set" repeatedly to get to the day she wants.	2	Flexibility and efficiency of use
	No obvious way of quickly turning heating off/cancelling if e.g. Susanne presses the 1-hour boost button by mistake, or changes her mind.	5	User control and freedom Help error recovery
	Susanne cannot save/load programs (e.g. if she wants to switch from a default to a holiday schedule and then back again, she will have to reprogram from scratch each time).	3	User control and freedom Flexibility and efficiency of use

	No child-proofing/locking mechanism.	2	Error prevention
	Does not appear to be an easy way for Susanne to view program settings without changing them; e.g. she may want to check the program for Monday by pressing "set", but end up changing it instead.	3	Visibility of system status User control and freedom Error prevention Flexibility and efficiency of use

Persona	Problem	Severity	Heuristic
Dan Jones	The current temperature is not displayed, only readable from the bezel border.	2	Visibility of system status
	Heating is only programmable for one burst a day; cannot have heating scheduled to come on for both the morning and the evening.	3	Flexibility and efficiency of use
	[+] and [-] buttons are required to be pressed/ held down to set temperature; although this is not an ability issue for Dan, it does take up time.	3	Flexibility and efficiency of use - Error prevention
	No confirmation that heating or one-hour boost is actually in effect.	4	Visibility of system status

Persona	Problem	Severity	Heuristic
Humphrey Oldman	The current temperature is not displayed. Humphrey may not be able to remember if he has a pre-set running or has overridden it, so may not be able to determine the current temperature.	3	Visibility of system status
	The indicator showing the current day is very small. Humphrey may not be able to determine which day he is changing the pre-set for.	2	Visibility of system status
	The [+] and [-] buttons require a large number of repeated presses to get to the correct time, or a precise release if the button is held continuously. Both could be a problem with Humphrey's lack of motor control.	4	Flexibility and efficiency of use / Error prevention
	There is no graphical representation or confirmation that the 1 hour boost is in effect. Humphrey may not realise that it has worked, or forget within the hour that he has initialised it.	3	Visibility of system status

Persona	Problem	Severity	Heuristic
Oliver Smith	While there are daily pre-sets there are none for 'special occasions' such as Christmas holidays, where the opening times of the office might be different. This means the heating would have to be controlled manually for the day, or the pre-set for that day would need to be changed. Neither could be done automatically, meaning Oliver would need to manually adjust the system.	3	Flexibility & efficiency of use
	There appears to be no 'smart' function to automatically reduce the temperature of areas of the building that aren't being used, therefore not helping reduce bills.	3	Flexibility & efficiency of use
	There no display of the current temperature at all, meaning no one will be able to determine the temperature of the building unless they look at the pre-set temperature settings and guess that the temperature is at the pre-set level (this may not always be the case).	4	Visibility of system status
	There is very little feedback about the overall heating of the building. Is the current temperature consistent throughout the building?	2	Match between system and real world Consistency & standards
	There are very few options to play with; Oliver is fairly technologically-minded and having the option of various options other than on/off, timed and pre-set would be useful.	3	User control and freedom

6.2: Dial-and-buttons prototype

Positives:

	Heuristic
Audible feedback on successful (or unsuccessful) attempts at using the functionality.	Visibility of system status

Large, tactile dial that is easy to use.	Flexibility and efficiency of use Error prevention
Flexibility provided by continuous, timed, and pre-set modes; pre-set mode allows multiple settings to be saved.	User control and freedom Flexibility and efficiency of use
Screen allows clear view of heating schedule and current temperature.	- Visibility of system status - Error prevention

Negatives:

Persona	Problem	Severity	Heuristic
Susanne Harrison	Only method of displaying time is the timeline, which is good for displaying the heating schedule; however, Susanne may also want to view the time in a more familiar format (e.g. "13:30").	1	Visibility of system status Match between system and real world
	Meaning of symbols for "continuous", "timed", and "pre-set" modes may not be immediately obvious to Susanne.	1	Match between system and real world Recognition rather than recall
	Smallest time increment is one hour.	3	User control and freedom Flexibility and efficiency of use
	How to program is not obvious without instructions.	2	Flexibility and efficiency of use Help and documentation
	No obvious way of turning the heating off quickly (temperature dial has not been labelled, so impossible to tell whether it will have an "off" option alongside temperature options).	5	User control and freedom Help error recovery
	Susanne may find the spoken feedback unnecessary and/or irritating, but there does not appear to be a way to turn it off.	1	User control and freedom
	No child-proofing/locking mechanism.	2	Error prevention
	Desired temperature is shown, but not actual temperature.	1	Match between system and real world

Persona	Problem	Severity	Heuristic
Dan Jones	A lot of re-setting and constant interaction with device to change schedule day to day.	4	Flexibility and efficiency of use
	Pre-set buttons are close to the mode selectors; this is unclear and could cause confusion.	4	Error prevention
	Overly complex system, and it is not intuitive to use; loss of the instructions would significantly reduce the usefulness of the product.	4	Error prevention

Persona	Problem	Severity	Heuristic
Humphrey Oldman	The constant, timer and pre-set selectors have no textual representation, and therefore require recall rather than recognition.	2	Recognition rather than recall
	The constant and timer icons look visually similar, and with deteriorating eyesight may not be distinguishable.	4	Error prevention
	The pre-set 'A' 'B' and 'C' buttons are in very close proximity to the three mode selectors, and it could be thought that they select the mode, not the switch above.	4	Error prevention
	Pre-sets can only last 24 hours, and must be manually switched between. If Humphrey is away for an extended period, he cannot come back to a warm house without turning the heating on every day.	4	Flexibility and efficiency of use
	It may not be clear that the pre-sets must be initially set by holding down the pre-set button.	3	Error prevention
	If Humphrey holds down the pre-set button for too long, it will begin the overwrite process. Even if he doesn't continue to set a new pre-set, he could get lost within this function, and not be able to exit.	2	User control and freedom
	The push buttons are very small and close together, and have small labels. Lack of motor control and weak eyesight mean that it will be very difficult for Humphrey to select the correct times.	4	Error prevention

	The push function buttons are too coarse – Humphrey cannot set half-hour intervals, for example.	4	Flexibility and efficiency of use

Persona	Problem	Severity	Heuristic
Oliver Smith	While there are a few pre-sets, they have to be activated manually meaning Oliver will still need to access the controls in early morning and late evening.	4	Flexibility & efficiency of use
	There appears to be no 'smart' function to automatically reduce the temperature of areas of the building that aren't being used, therefore not helping reduce bills.	3	Flexibility & efficiency of use
	There is only a single display of the temperature, which is located on the control panel, meaning that people in the office will not be able to see it.	1	Visibility of system status
	There is very little feedback about the overall heating of the building. Is the current temperature consistent throughout the building or is it just that temperature at the control panel where the thermometer is?	2	Consistency & standards
	There are very few options to play with; Oliver is fairly technologically-minded and having the option of various options other than on/off, timed and pre-set would be useful.	3	User control and freedom
	The overall design is very cluttered and not particularly easy to understand.	2	Minimalist design
	Push buttons are very small, making it difficult to determine when the timer has been set.	2	Visibility of system status

6.3: Touchscreen prototype

Positives:

	Heuristic
Days can be programmed individually, for different zones, and schedules can be saved/loaded; schedule can easily be temporarily overridden.	User control and freedom Flexibility and efficiency of use
Quick options allow user to e.g. quickly turn all heating off, or use an economy option.	User control and freedom Flexibility and efficiency of use - Help error recovery
User can view manual, and a record of their heating usage; there is a "help" button on every page.	Error prevention Help and documentation
Pop-ups help prevent the user from choosing the wrong settings; "yes" and "no" buttons in pop-ups are positioned consistently.	Consistency and standards Error prevention

Negatives:

Persona	Problem	Severity	Heuristic
Susanne Harrison	Target/actual temperatures are not visible on every page.	2	Visibility of system status
	The "OK" button on the "Edit Monday" screen does not actually save changes to the schedule; changes can only be saved on the "settings" screen. This may be confusing/ may not be obvious to Susanne.	3	Error prevention Flexibility and efficiency of use
	No option to name zones; Susanne may have trouble remembering which zone corresponds to what area of the home. Problem is worse the more zones there are.	4	Match between system and real world Error prevention Recognition rather than recall
	No quick "off" or "cancel" option for the temporary override.	5	User control and freedom Flexibility and efficiency of use Help error recovery

	Method of adjusting temperature (either for the override, or for adjusting a schedule) is not the fastest; Susanne has to scroll up or down until she reaches the desired temperature, and scroll to the desired time(s).	2	Flexibility and efficiency of use
	No way to quickly set identical day schedules to all/some days; they have to be programmed individually.	2	User control and freedom Flexibility and efficiency of use

Persona	Problem	Severity	Heuristic
Dan Jones	Large amount of menus and submenus; whilst Dan can navigate them, this takes time, slowing down use of system.	3	User control and freedom Flexibility & efficiency of use
	There is a great deal of control for different zones; however, Dan's flat is not expansive and one 'zone' is all that would be required. Setting all zones to be the same would take up a lot of time.	2	Visibility of system status Flexibility & efficiency of use
	No tactile operations slow down on-the-fly adjustments.	3	Visibility of system status

Persona	Problem	Severity	Heuristic
Humphrey Oldman	The hierarchical screen structure could prove confusing to someone with a lack of technological ability. An ever present menu or 'breadcrumb' structure could help ensure Humphrey doesn't get lost.	4	User control and freedom
	The screen often offers a lot of information at once. Whilst this offers more functionality, Humphrey may not be able to digest all of this information without getting confused and giving up.	4	Aesthetic and minimalist design
	There is no tactile or audible feedback – Humphrey may not be able to see or feel that he is making any changes.	2	Visibility of system status
	Setting up a pre-set requires a lot of effort throughout the process. Humphrey is likely to get confused as to where he is in the process, and give up.	4	Flexibility and efficiency of use

Persona	Problem	Severity	Heuristic
Oliver Smith	While there are daily pre-sets there are none for 'special occasions' such as Christmas holidays where the opening times of the office might be different. This means the heating would have to be controlled manually for the day or the pre-set for that day would need to be changed. Neither could be done automatically, meaning Oliver would need to manually adjust the system.	3	Flexibility & efficiency of use
	While the system offers a significant number of options, the display seems to be fairly cluttered and slightly difficult to understand.	1	Minimalist design
	There appears to be no 'smart' function to automatically reduce the temperature of areas of the building that aren't being used, therefore not helping reduce bills.	3	Flexibility & efficiency of use

6.4: Summary of Features to be included in the second prototype

For the second prototype, we decided to combine a touchscreen (which can provide a wide range of functionality in a limited space) with a physical dial, which allows the temperature and time to be adjusted easily (compared to repeatedly pressing buttons on a screen); some users may also feel more comfortable with tactile controls. Some of the other features we chose to carry over from the first prototypes include:

- Being able to choose between continuous, timed, and pre-set modes. This time we chose label the choices textually, since we concluded that symbols might not be clear to users. Having three clearly labelled modes provides flexibility of choice while also keeping the interface easy to understand

- An "options" button on the homepage which leads to a menu that includes, among other things, a user manual - this means that the user will always have easy access to instructions if, for example, they misplace the physical ones – and usage reports.

- A quick "off" option, this time on the homepage - people frequently change their minds or make mistakes, and it is important that they are able to reverse any decisions they make.

We also chose to add a clickable breadcrumb trail, so the user can see how they got to a particular page, and easily go back to a previous page. While we agreed that having different heating zones is a useful feature, it makes design/implementation a lot more complex, so we ultimately decided not to include it in the second

prototype, as we thought it was more important to focus on other, more fundamental, features. We decided that the prototype would be aimed at home users (as opposed to commercial users), so in the end we did not consider Oliver Smith's requirements when designing it; a commercial system calls for much more complex functionality and we did not think it was feasible to produce a prototype that fulfils the requirements of both home and commercial users.

7: Description and Rationale for Second Prototype

7.1: Evaluation of potential tools for prototype

A number of possible tools were considered for the creation of the second-generation prototype, each has been evaluated for its pros and cons below:

Balsamiq

Balsamiq was considered for the tool used to create a second-generation prototype. Balsamiq is a quick and easy to use tool to create wire frame designs that allows a user to quickly and cleanly create an idea of how a systems user interface may look.

It is predominately aimed at interfaces found on a computer or mobile phone screen, therefore it was felt that it would be less useful for this project as the touchscreen did not conform to the usual design for a computer program layout.

The positives for the use of Balsamiq are primarily centred around its ease of use, because it is focused on the design for a computer program or mobile app it has many useful layouts for drop boxes, common button layouts and various other frequently used elements. These help the user create something quickly that resembles programs that most people use daily. These positives make Balsamiq a very strong tool when designing a windowed program for a computer or mobile phone, however this project is focused on the design for a heating system.

The basic heating system design is focused on having two parts, the first is that of an adjustable dial that can be easily used for adjusting the temperature quickly. The second part is a touch screen that contains more of the features such as daily heating programs or zonal heating commands. These two parts make up the overall design for the second-generation prototype.

Balsamiq could be used for this design, however it is limited when designing a system that is not using the typical features found on most computer programs. Its strengths lie in having these features ready at hand for designers to use. However in this instance it is unlikely that many of them would be useful meaning that most of the design would have to be done from scratch. This means that it is in affect no more useful than any other computer aided design package, and because it focuses on windowed programs predominately it may well be weaker than other packages when trying to design a different type of interface.

Overall it was decided that while Balsamiq is a useful tool for creating prototypes its strengths do not match well with the prototype design proposed for this project. It would require the team to learn how to use the software from scratch and

most of the most useful features would not be used for the design. Therefore the team decided not to use this package.

Strengths:

- Strong in designing windowed programs typically found on computers and mobile phones.
- A vast library of buttons and layouts typically used in computer programs meaning the designer does not need to create them from scratch.
- The software is free (at least as a trial).
- The interface is simple to understand for a computer aided design program.
- There are a good number of tutorials available for creating apps and windowed programs.

Weaknesses:

- It is not particularly flexible when designing an interface that is not typical to a computer or phone.
- Would require a user to learn the menus and options as it was a package that no one in the group had heard of before.

PowerPoint

PowerPoint (and other similar presentation software) is at first glance an obvious choice for the touchscreen implementation of the second-generation prototype. It has the advantage of being software that all group members are familiar with to some extent, and a basic interface - where clicking a button will take you to another page - can very easily be created. However, when considering some of the more complicated functionality we may wish to include in the prototype, PowerPoint falls short. For example:

- Changing the temperature or time requires the text on the screen to change in real time; again, this calls for several animations that make textboxes appear and disappear with the press of a button (as well as having to layer the textboxes on top of one another, which makes editing tedious).
- There does not seem to be a way (if there is, it is not obvious) to save changes between slides; if the temperature is changed on one slide, it is not then automatically changed on other slides. A button can only trigger an animation on an object on the same slide.

Our conclusion is that other software is better suited to our needs.

Maya

Maya is a tool used to generate 3D models, shapes and assets for use in movies, design and architecture.

Maya has the ability to build components in a wireframe style and apply textures over the top. The overlaid textures can be used to show a material type to imply construction, or graphics to show a UI. The ability to create these shapes and then combine them into more complex structures is of great benefit, this enables the user to create otherwise unimaginable shapes.

The package is extremely powerful, allowing for a wide variety of effects, textures and offers full control when designing parts. This is of particular interest as glass will be a key part of our design. Maya has a light/shadow set of tools built in, this allows for a visual effect of light reflecting off surfaces.

The ability to export rendered scenes from Maya in a wide selection of formats is also vital, this allows the 3D model to be exported and then used in other software packages such as Photoshop and Flash.

The wide functionality of Maya suits the needs to create versatile models that can be changed quickly is the reason that this software package has been chosen to design the second stage prototypes. Maya is the choice of many professional graphics, design and computer games design companies / studios, this and the free license given to students makes one of the industries most powerful design tools available to use, this is also why Maya was chosen.

Flash and Photoshop

Flash offers complete integration with Photoshop (including importing of layers) and Illustrator, which will speed up the prototyping process due to increased compatibility between programs. This is advantageous over rebuilding the image in PowerPoint, as fine control over layout can be achieved in Photoshop.

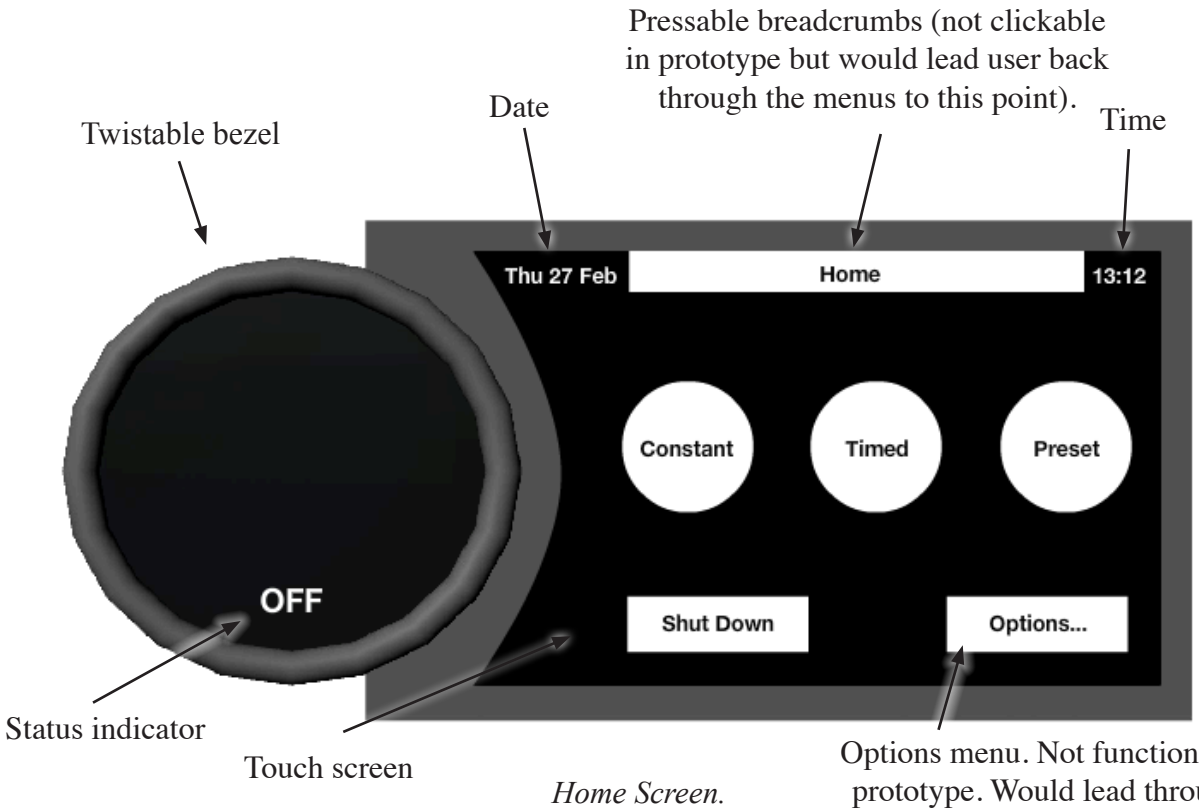
Different scenes can be set up as key frames, and different areas of the prototype can be configured as buttons, that when pressed can jump to the correct scene. Animations can be incorporated on tactile operations (such as the turning of a dial) in a more precise and professional looking way than with PowerPoint.

The frame/stage workflow of Flash hands itself to this tactile object based design – each element will have its own place on the stage, where the dial can be ever present, and the screen can change from key frame to key frame, without the dial having to move as well, which is the default behaviour in PowerPoint, when a button click merely moves from slide to slide.

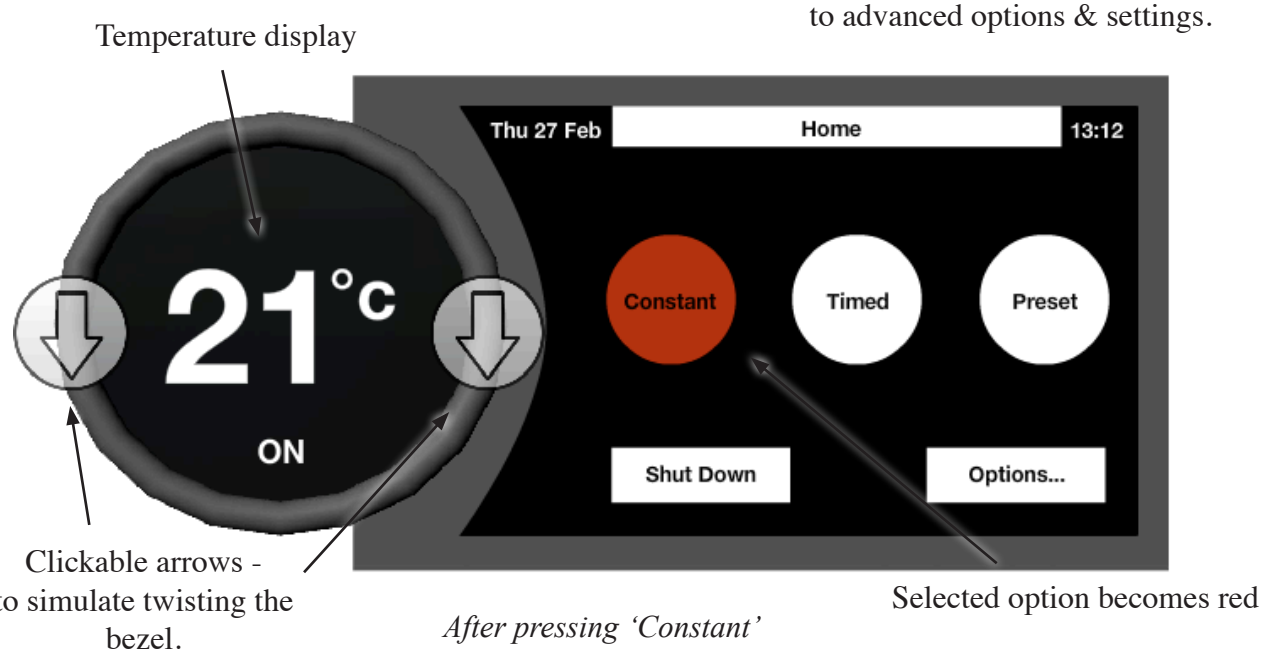
Using Flash in this way requires a small specialist skill set, whereas PowerPoint is a universally taught skill. Therefore there is a learning curve to using the software in order to create the prototype. However, to provide the functionality required, all that is necessary is a couple of lines of ActionScript (stop() and goToAndStop()), and a member of the team already possesses this knowledge. Furthermore, thanks to the Adobe CreativeCloud 30 day free trial, all of these programs will be available until after the project hand in date.

Flash is not available on all platforms, which limits the devices that the prototype can be used on to PCs with Flash installed. However, this is also an issue with using PowerPoint, as PowerPoint must be installed on machines to run prototypes based on it.

7.2: Guide Through Second Prototype Functionality

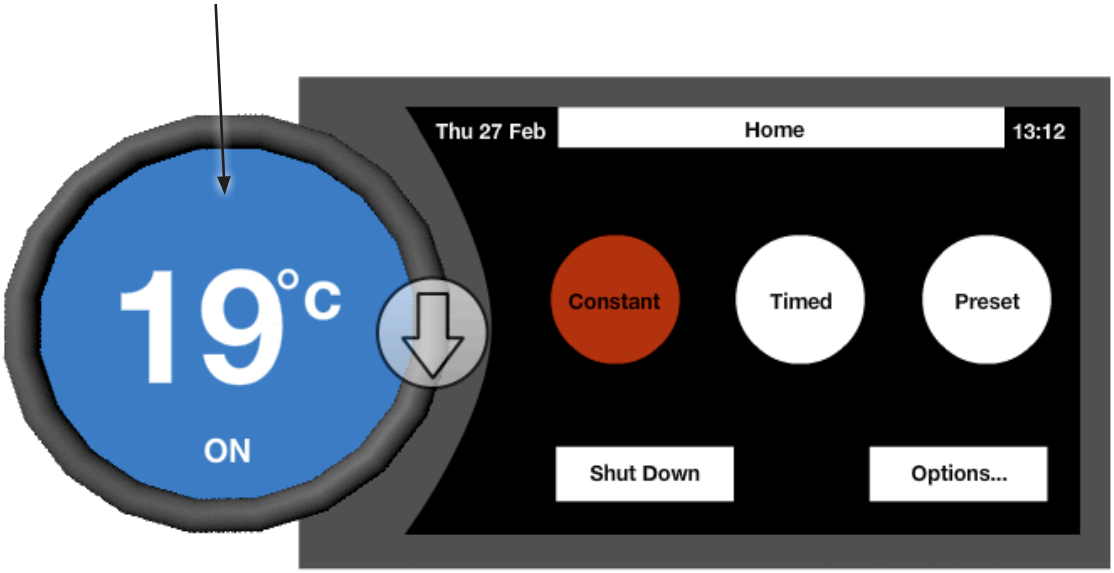


Home Screen.

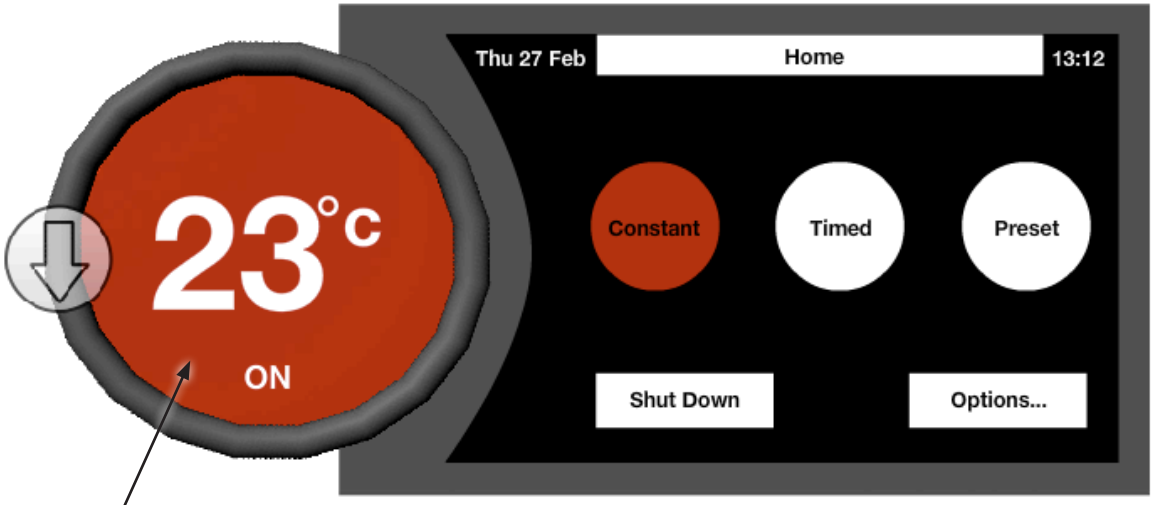


After pressing 'Constant'

When temperature goes below set value (21 degrees), screen becomes blue.



After pressing left arrow (the bezel rotates). Right arrow takes the user back to previous screen.

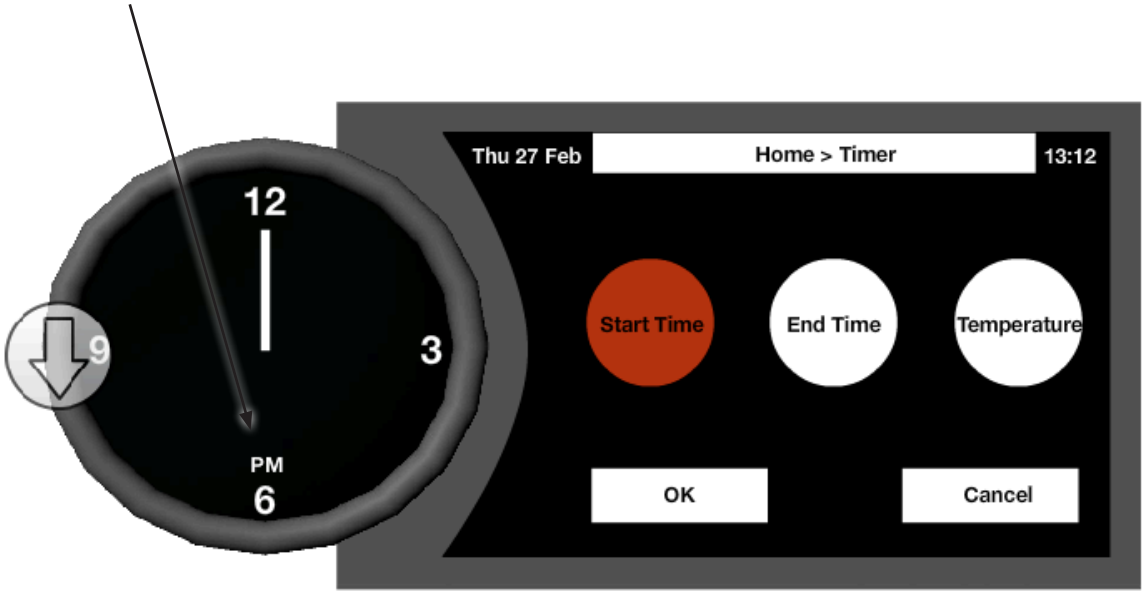


After pressing right arrow.

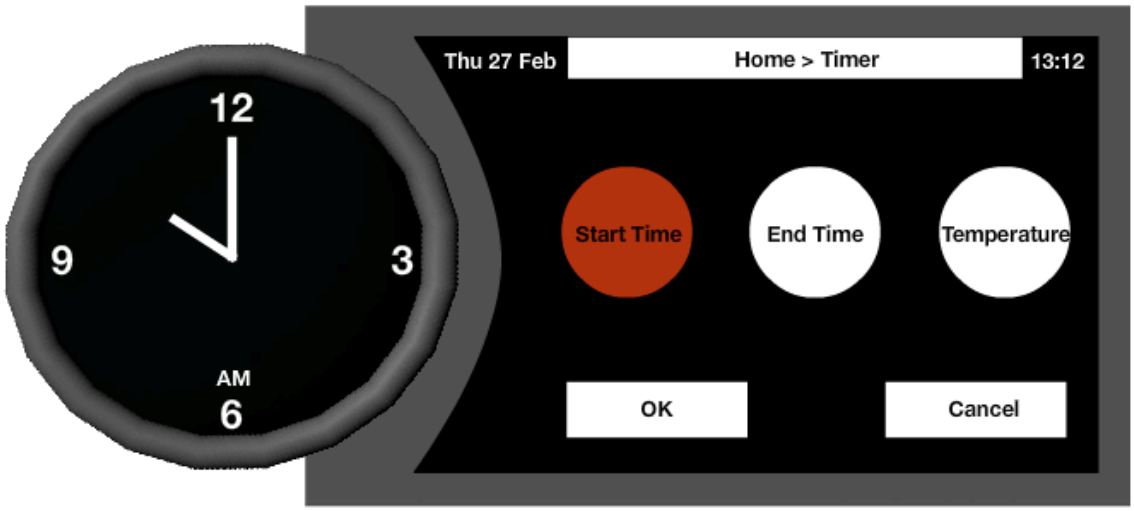
Pressing 'Constant' again at any point takes user back to initial screen.

When temperature goes above set value (21 degrees), screen becomes red.

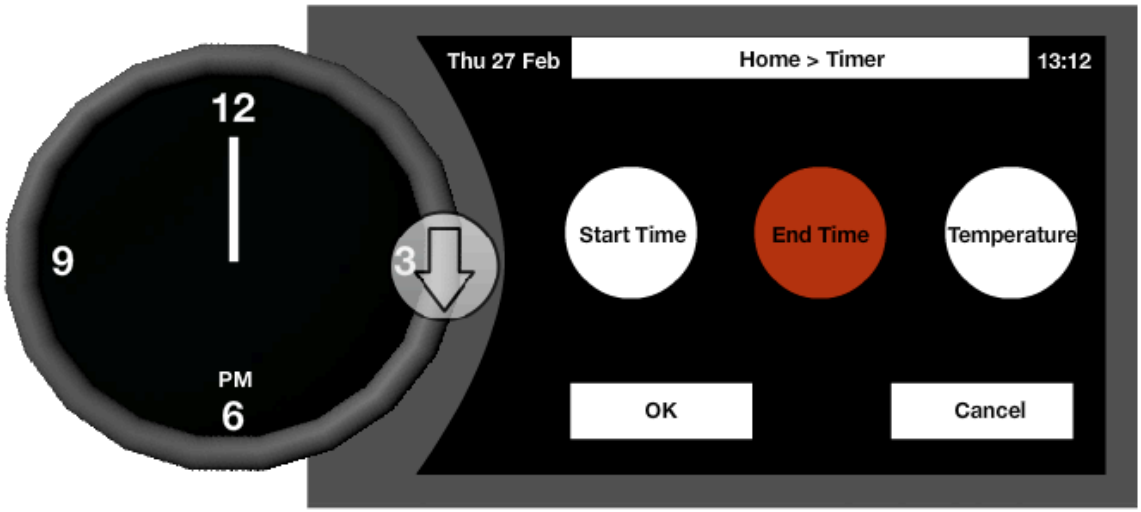
AM/PM indicator on clock face



After pressing 'Timed'. User can click the down arrow, or move on to End Time or Temperature.
At any point, user can switch between setting Start Time, End Time and Temperature.

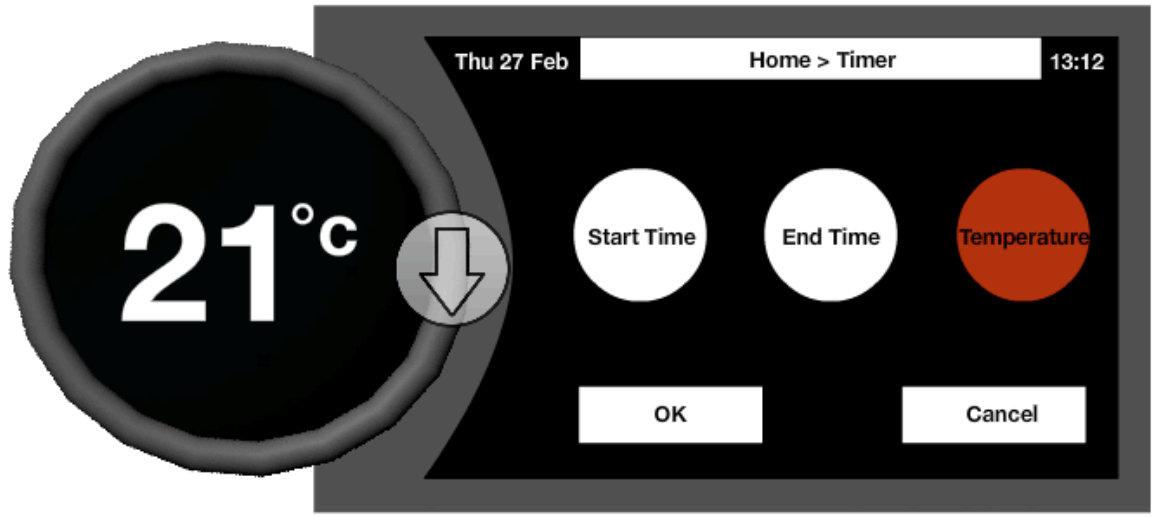


After pressing down arrow to set the start time. The bezel animates with a left rotation, and the clock face spins with it.



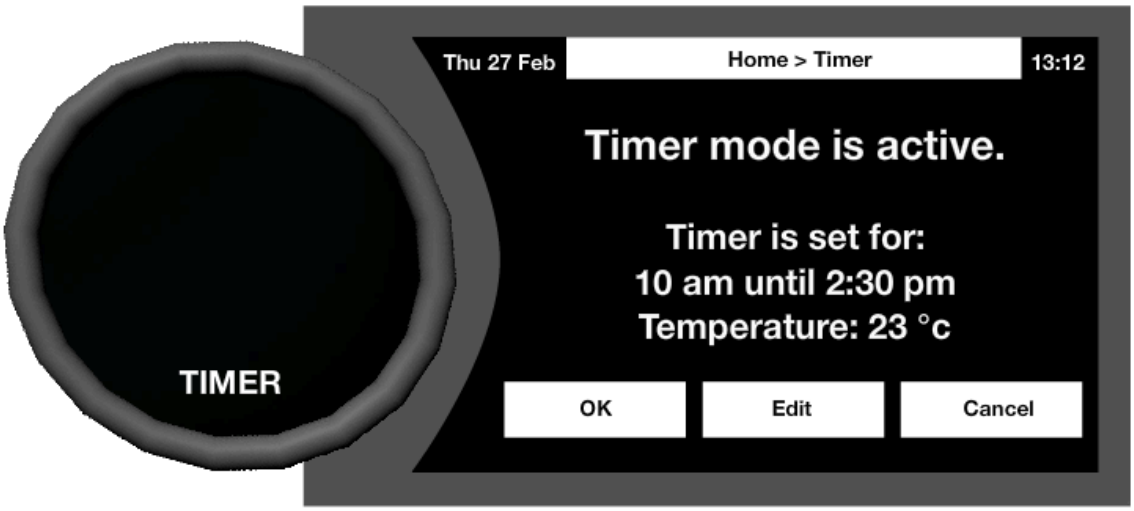
After pressing 'End Time' at any point.

After pressing up arrow to set the end time. The bezel animates with a right rotation, and the clock face spins with it.

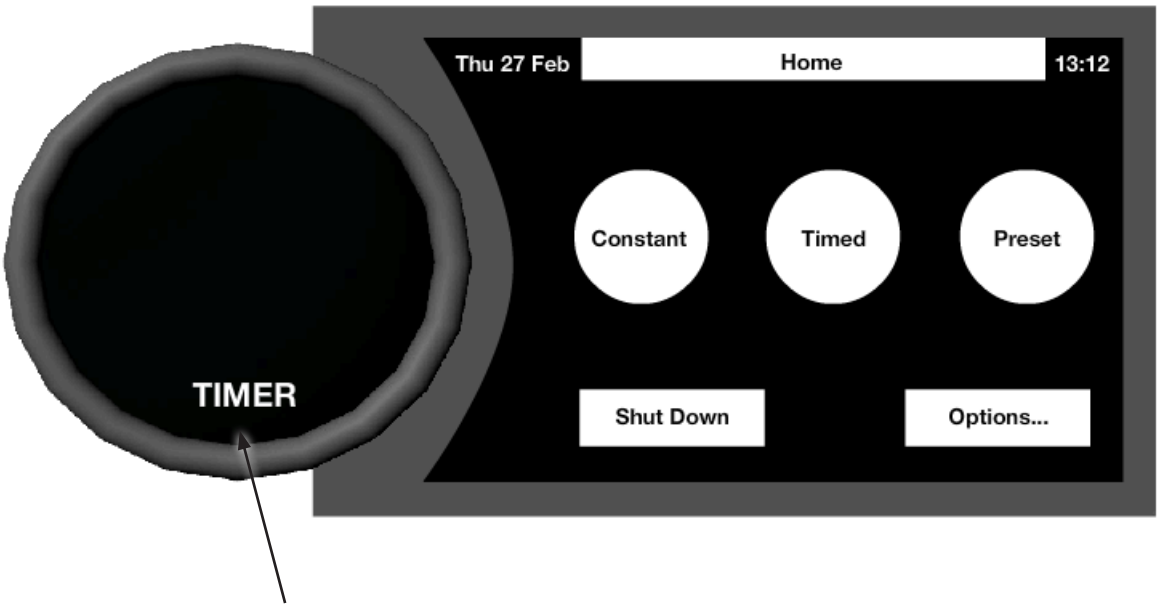


After pressing 'Temperature'.

After pressing arrow to rotate bezel clockwise.

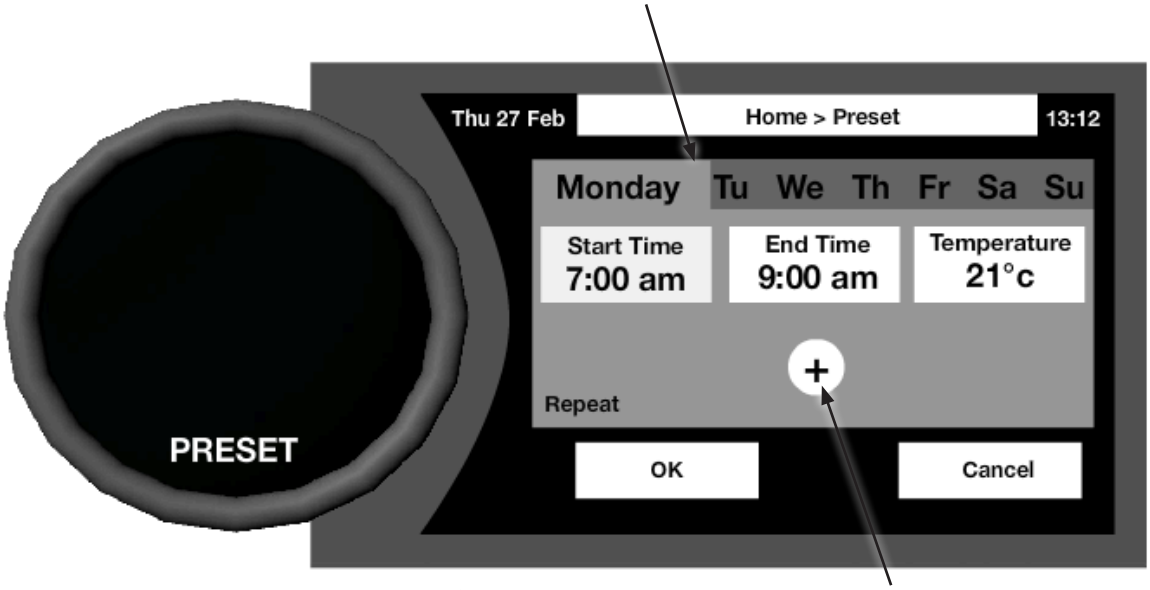


After pressing 'OK'. Pressing OK again takes the user to the following screen. Pressing 'Cancel' at any point returns to home screen.
Pressing 'Edit' takes the user back into the timer options window.



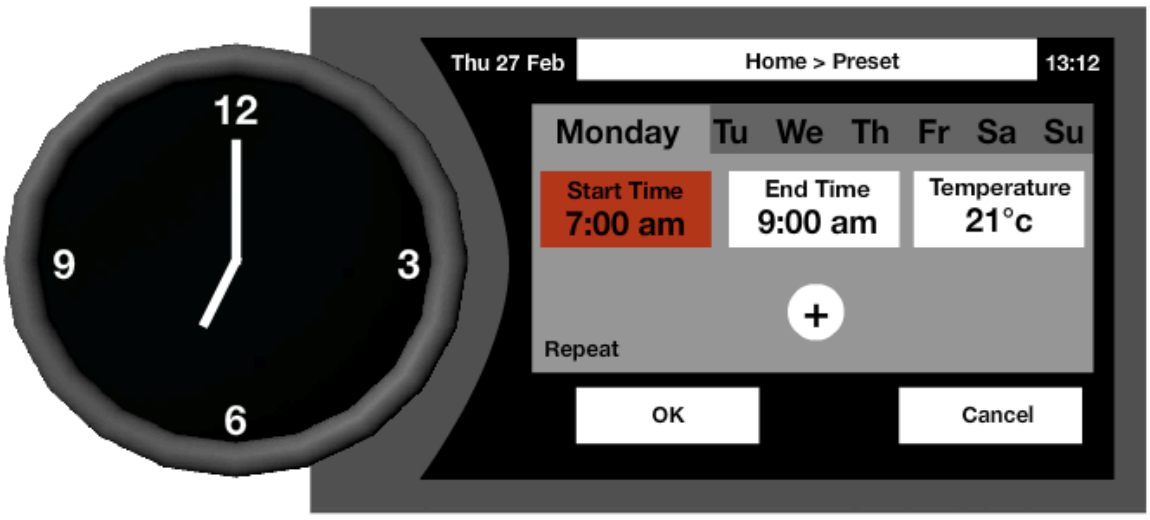
Home screen again, but status indicator shows a timer is set.

Tabbed window. Each day of the week can be accessed via its tab (in this prototype only Monday and Tuesday are clickable). From there, start and end times and temperature can be selected.



After pressing 'Preset'.

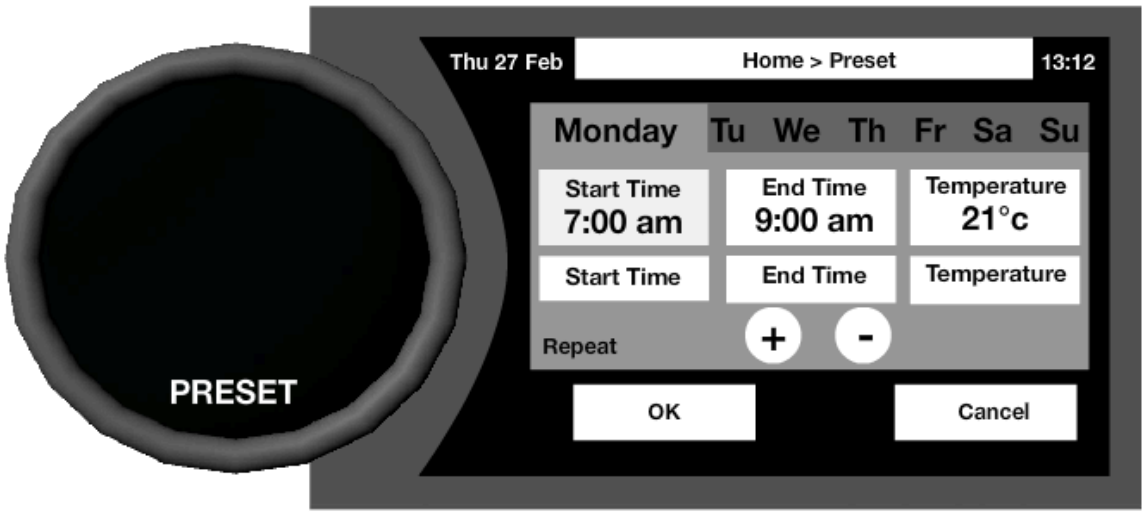
Button to add new row. Explained below.



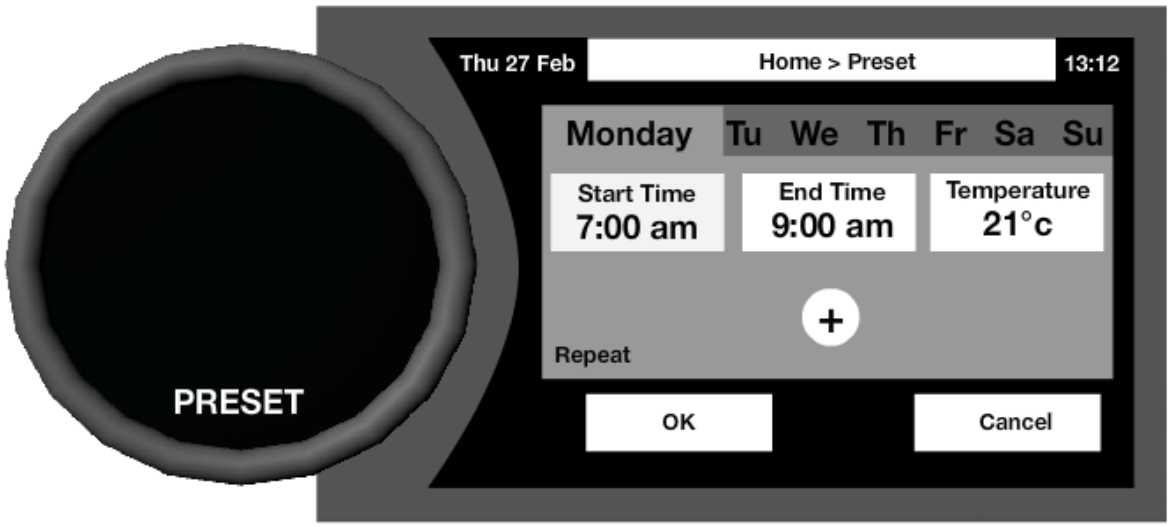
After pressing 'Start Time'. The user would be able to twist the bezel to set the start time, however this is not implemented in this prototype.

After pressing 'End Time'. The user would be able to twist the bezel to set the end time, however this is not implemented in this prototype.

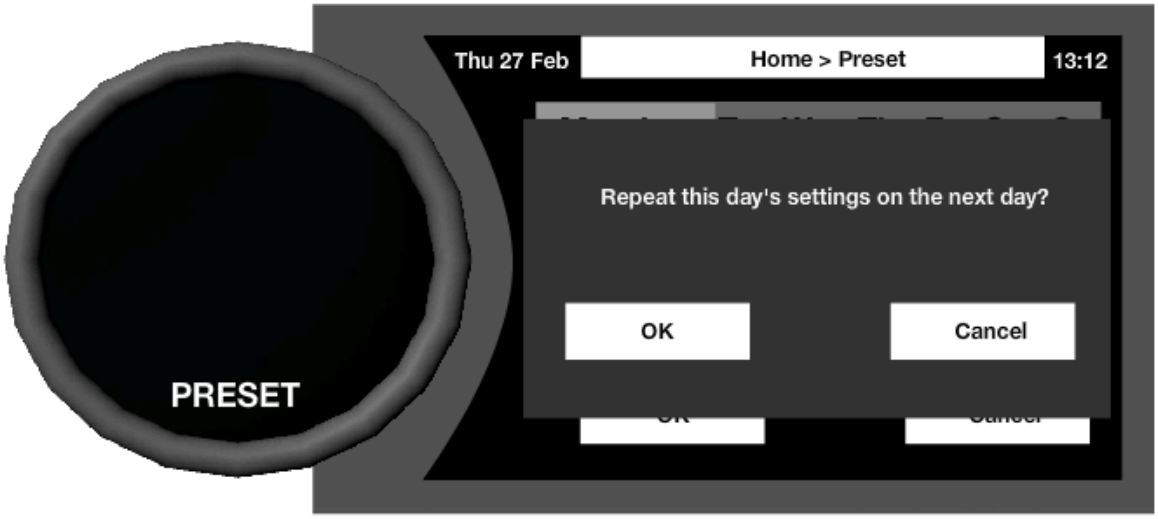
After pressing 'Temperature'. The previous 3 screens are accessible from each other.



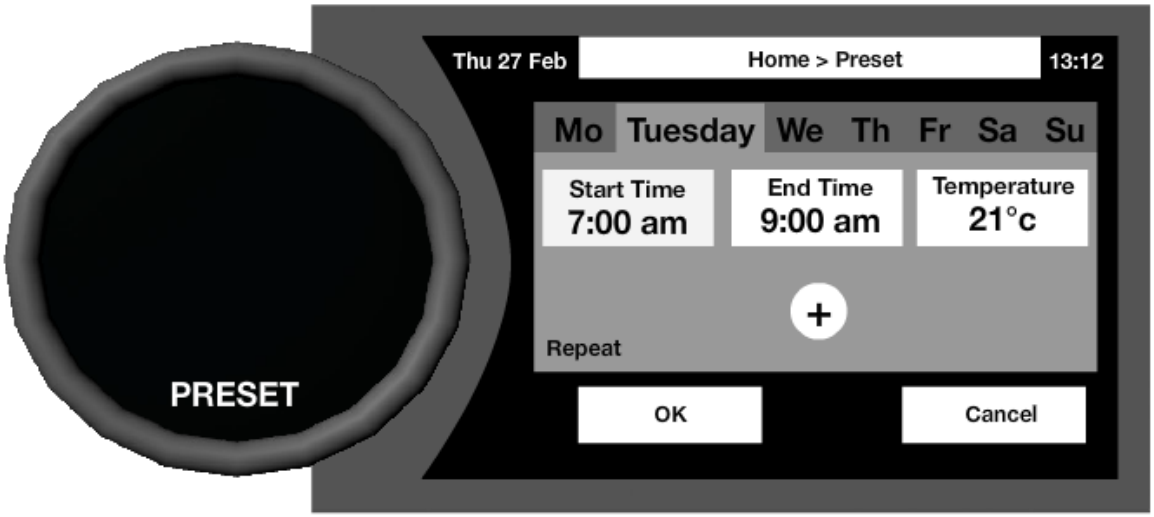
Pressing '+' adds another row of options, which would operate in the same manner as the previous row (this is not implemented in the prototype).



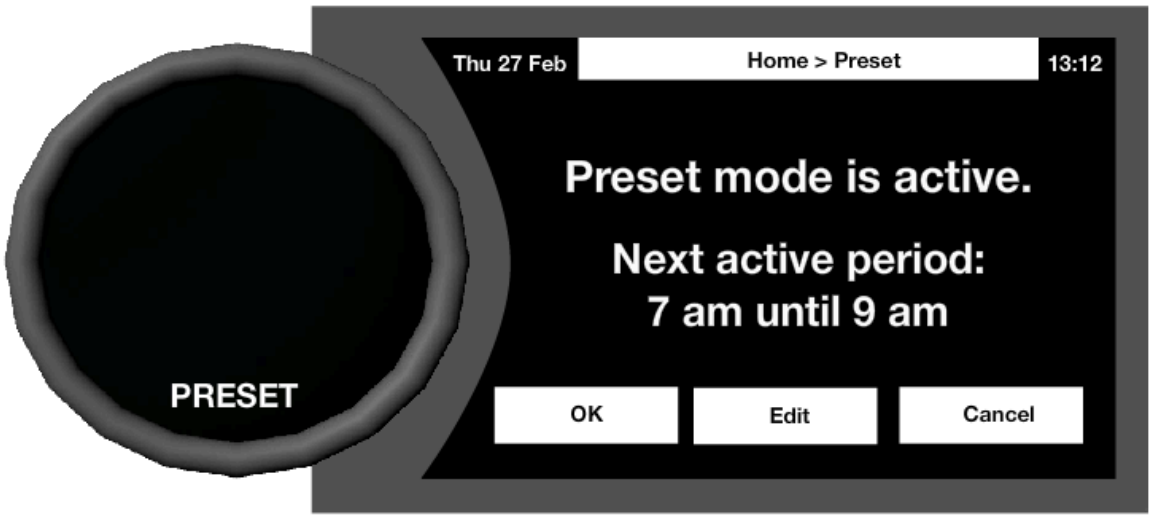
Pressing '-' removes the additional row.



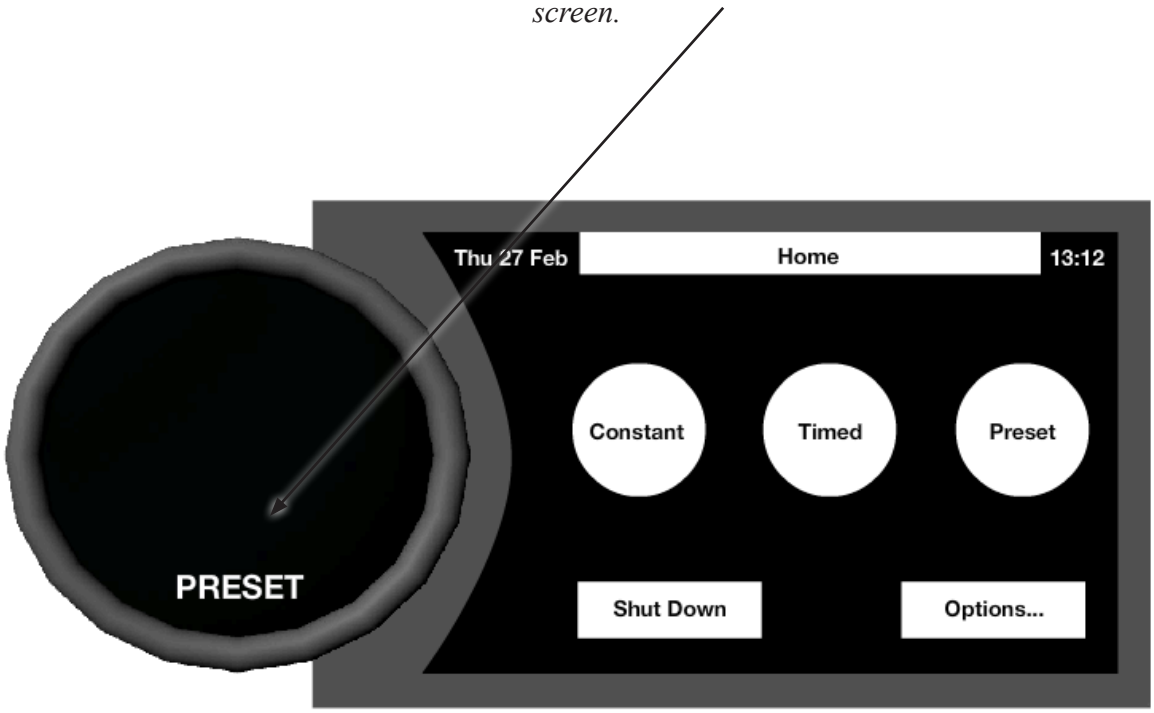
'Repeat' brings up a dialog asking if the user wants to repeat the day's settings. Cancel takes user back to initial preset screen.

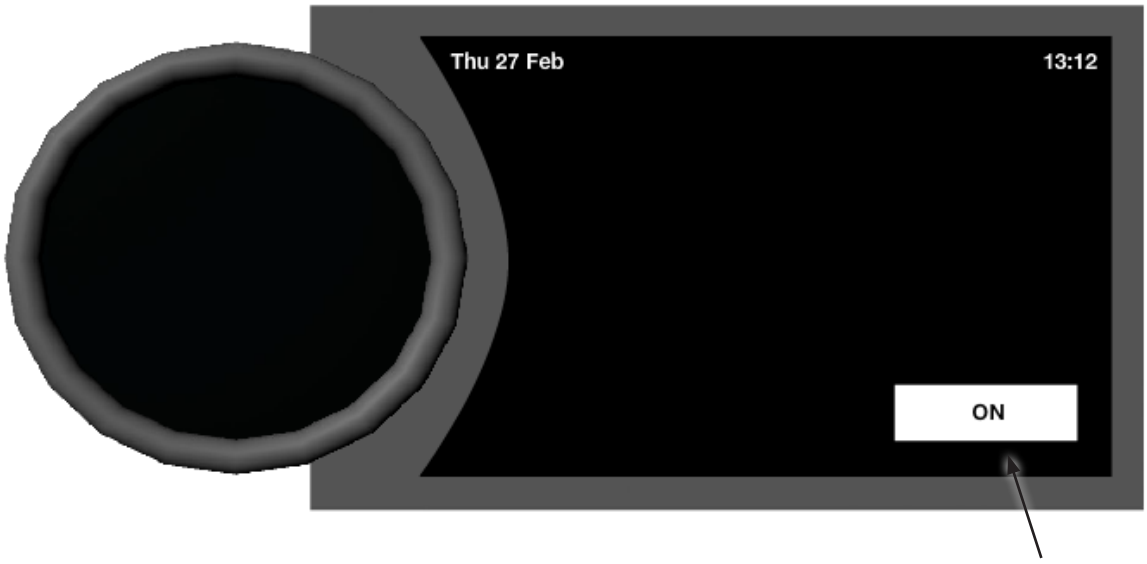


Pressing 'OK' takes user to Tuesday's tab with the same settings. This can also be accessed by pressing 'Tu' from Monday's tab.
From here, clicking 'Mo' returns to monday's tab, and clicking '+' adds another row to Tuesday's tab, as previously.



On pressing 'OK' at any point. Pressing cancel returns to the home screen. Pressing 'Edit' returns to Monday's tab on the preset screen.
Pressing OK returns the user to the home screen, but 'Preset' is visible within the circular screen.





From the home screen, pressing 'Shut Down' brings up the 'off' screen. Pressing on brings up the home screen.

8: Evaluation of second prototype

The personas were again used to evaluate the second prototype both for its pros and its cons. Again the evaluation was based around the Nielsen Heuristic model using the 6-point scale that was outlined before the first prototype evaluation.

As well as the use of personas however a simple user evaluation was created, a member of the design team guided a user through a user experience and then asked them to fill out a questionnaire asking them to rate their experience on a number of areas. An example of the questionnaire can be found before the results of the evaluation below.

8.1: Persona Evaluation

Positives

Persona	Positive	Heuristic
Oliver Smith	There appears to be some ability to have preset programs	Flexibility & efficiency of use
	Good summary page of what preset/timer has been created	Visibility of system status
	Nice large display of the current temperature	Visibility of system status
	Very clear button/background contrast	Visibility of system status
	Easy to adjust the current temperature settings through use of large twistable knob	Flexibility & efficiency of use

Persona	Positive	Heuristic
Dan Jones	Outer bezel is a quick convenient and familiar way to change the clock and temperatures	Usability of system
	Large clear touch screen with clear instructions	Usability of system
	second round screen shows programme currently selected	Visibility of system status
	Clear buttons that show which buttons I need to press for each setting	Visibility of system status
	Confirmation screens/ messages show the selected options and details	Visibility of system status
	I am able to pre set different times and temperatures for each day for the week	Flexibility and efficiency of use
	Repeat button significantly reduces the buttons pushes to set up the system	Flexibility and efficiency of use

Persona	Positive	Heuristic
Susanne Harrison	Pre set mode allows programming for each day individually; heating can be programmed to come on multiple times a day	User control and freedom Flexibility and efficiency of use
	Shut-down button allows whole system to be turned off quickly	Flexibility and efficiency of use Help error recovery
	Options button leads to menu that allows user to view manual or usage reports	Help and documentation
	"Repeat" option allows schedule to be copied to the following day	Flexibility and efficiency of use
	Large tactile dial makes temperature quick and easy to set	Flexibility and efficiency of use Error prevention
	Flexibility provided by continuous, timed, and pre set modes	User control and freedom Flexibility and efficiency of use

Persona	Positive	Heuristic
Humphrey Oldman	Visible breadcrumb trail at the top of the screen ensures Humphrey doesn't get lost in the system.	Visibility of system status
	High contrast between background and text.	Visibility of system status
	Large readout of all information, with clear emphasis on the most important aspects (very large temperature display)	Aesthetic and minimalist design Visibility of system status
	No fiddly controls – large, tactile bezel for setting time / temperature, and large touchscreen buttons for navigating menus.	Flexibility and efficiency of use Error prevention

	Timer and presets can be configured with a high precision, so system can turn on exactly when needed (e.g. 30 minutes before Humphrey expects to get back from the cafe).	User control and freedom Flexibility and efficiency of use
	Current system status is visible on the circular readout, so Humphrey knows whether the system is on, set to timer, or set to run a preset.	Visibilty of system status
	There are is no icon based readout – as long as Humprey can see something, he can read what the button does.	Recognition rather than recall

Negatives

Persona	Problem	Severity	Heuristic
Oliver Smith	While there are a few presets, they have to be activated manually meaning Oliver will still need to access the controls in early morning and late evening	4	Flexibility & efficiency of use
	There appears to be no 'smart' function to help reduce the temperature of areas of the building that aren't being used, automatically, therefore not helping reduce bills	3	Flexibility & efficiency of use
	There is only a single display of the temperature, which is located on the control panel meaning that people in the office will not be able to see it.	1	Visibility of system status
	There is very little feedback about the overall heating of the building. Is the current temperature consistent throughout the building or is it just that temperature at the control panel where the thermometer is?	2	Consistency & standards
	There are very few options to play with, Oliver is fairly technologically minded and having the option of various options other than on/off, timed and preset would be useful.	3	User control and freedom

Persona	Problem	Severity	Heuristic
Dan Jones	Unclear if shutdown turns screen off or shuts down the system	2	Flexibility and efficiency of use
Dan Jones	No 1 hour boost button	4	Flexibility and efficiency of use

Dan Jones	Does not show the temperature the house/room is currently at	2	Error prevention
Dan Jones	No feedback on how efficient my heating plan is	2	Flexibility and efficiency of use

Persona	Problem	Severity	Heuristic
Susanne Harrison	Method of changing the time is not particularly efficient - Susanne cannot set hours and minutes separately	2	Flexibility and efficiency of use
Susanne Harrison	Susanne cannot save/load programs (e.g. if she wants to switch from a default to a holiday schedule and then back again, she will have to reprogram from scratch each time)	3	User control and freedom Flexibility and efficiency of use
Susanne Harrison	When on the timer or pre set mode, the dial displays the text "timer" or "pre set", but does not display the temperature	4	Visibility of system status Recognition rather than recall
Susanne Harrison	No child-proofing/locking mechanism	2	Error Prevention
Susanne Harrison	Only one heating zone	4	User control and freedom

Persona	Problem	Severity	Heuristic
Humphrey Oldman	Feedback completely visual – lack of audible feedback means Humphrey must rely totally on his eyesight.	3	Visibility of system status
Humphrey Oldman	When setting the timer, the information about start time / temperature is not visible when setting the end time, for example. This means that Humphrey must wait until he has set all three to check if he has input the correct parameters. By the time he is adjusting the third, he may have forgotten what he entered for the first.	3	Visibility of system status Recognition rather than recall Error prevention

Humphrey Oldman	To cancel a timer/preset, he must go back into the menu for that mode and press 'cancel'. It may be easier for him to be able to cancel any upcoming processes straight from the home screen.	2	Flexibility and efficiency of use
Humphrey Oldman	There is no feedback on how economical Humphrey's usage of the system is. He may think he is being economical, but has no reassurance that he is.	2	Flexibility and efficiency of use
Humphrey Oldman	Help and documentation is contained behind the 'options' menu. Although this reduces the amount of clutter on the screen, it may be easier for Humphrey to get help on the screen where he is stuck.	4	Help and documentation Error prevention

8.2: Summaries

Dan Jones

The design is intuitive and clear, the dual screen interface coupled with the large format touch screen and rotating bezel make it easy to understand and use. Dan is able to quickly and easily set the heating schedule for his week using the repeat button to transfer the heat schedule to the next day, the ability to have a separate schedule for the weekend is very helpful. However the absence of a 1 hour boost button is inconvenient, he uses the heating to dry clothes as he lives in a flat with no access to outside, and he may forget to turn the heating back off if using the ‘constant’ setting.

Humphrey Oldman

Humprey mainly uses the 'constant' setting, which he is able to turn on, off, and set the temperature easily, without making errors (although he can sometimes forget to turn the system off once he is finished using it, or when he leaves the house). However, even though they improve on implementations in some older systems, the timer and preset functions present Humphrey with some trouble. When setting the timer, he is unable to see what he set at the start time when he is setting the end time and temperature, and he may forget what the previous parameters were before he can finish.

The tabbed system in the preset mode causes him confusion - his poor eyesight means that sometimes he cannot make out which tab is open, so does not know which day he is setting the preset for. All feedback is visual in nature, so whilst he can see the readouts when setting the constant temperature (as that is very large and high contrast), he cannot always read the smaller, touch screen buttons when delving further into the system. Audible feedback may help him with this. While the twisting bezel system provides Humphrey a way to twist to set the time, the fact that the hour and minute is set in one movement is quite a lot of visual information to keep up with.

Susanne Harrison

Susanne finds the system fairly straightforward to use, and is pleased that she is able to set a different schedule for each day, while also being given an easy option for temporarily overriding the schedule. She appreciates being able to view her usage history, as this gives her a better idea of how she may save money. Her biggest problems with the system are the lack of zoning - Susanne feels it is wasteful to heat the entire house when she just wants one or two rooms to be heated - and the lack of an option to save or load schedules. She also would have liked it if some kind of childproofing had been implemented; however, this could easily be added in later prototypes. Overall, the system provides Susanne with much of the flexibility she desires.

Oliver Smith

The system was clearly not designed with Oliver's needs in mind, this was identified earlier in the report. It does however still have some merits to it that he would find useful. The ability to set different programs for different days means he can set one program for weekdays and one for weekends when the office building will be shut. It also has a large display indicating the temperature, while this is only useful for those near the control panel, it is a good step in displaying the information about the heating system like he wished. Ultimately however as previously pointed out this system was not designed for large commercial use and therefore will have limited to no potential benefit for Oliver overall.

8.3 User Evaluation

Evaluation and results of user questionnaire

A selection of potential users were asked to take part in a small demonstration, interaction and survey activity to determine the applicability of the system that the prototype emulates.

The survey took the format of a brief explanation from a team member explaining what the system is and how it works. It was explained that there are dual displays, the smaller display is surrounded by a rotating bezel, and the larger display is a touchscreen where the majority of the information is displayed and interaction takes place. The users were asked to interact with the flash prototype, a team member sat with the user to explain the limitations of the system and to offer any guidance. Once the user felt they had sufficient experience with the system they filled out a questionnaire (see appendix).

The questionnaire is an adaption on the system usability scale (Digital Equipment Corporation, 1986), these 10 questions related to the software/interface of the system. The questionnaire also included two additional questions at the end, relating to the hardware/design of this system specifically.

- Question 11-
  "*I feel the dial makes it easy to change the temperature and time"*
- Question 12-
  "I would feel comfortable using the touch screen in real life"

These additional questions relate to the hardware options chosen, they were included to provide feedback on how user friendly and applicable the hardware choice of the touchscreen and bezel as the input method to the system.

The questionnaire also asks for the user's age, this is so the results they provide can be matched to a persona, as the personas generated have clear age brackets. Being able to match results to personas we are able to evaluate how well each persona was catered for by the design. At the end of the questionnaire, each user makes a brief note on their technical ability and leaves additional comments on the system.

The users surveyed were aged 19 -53, with an average age of 33, have different occupations and are from a variety of professions, with a varying degree of technical ability.

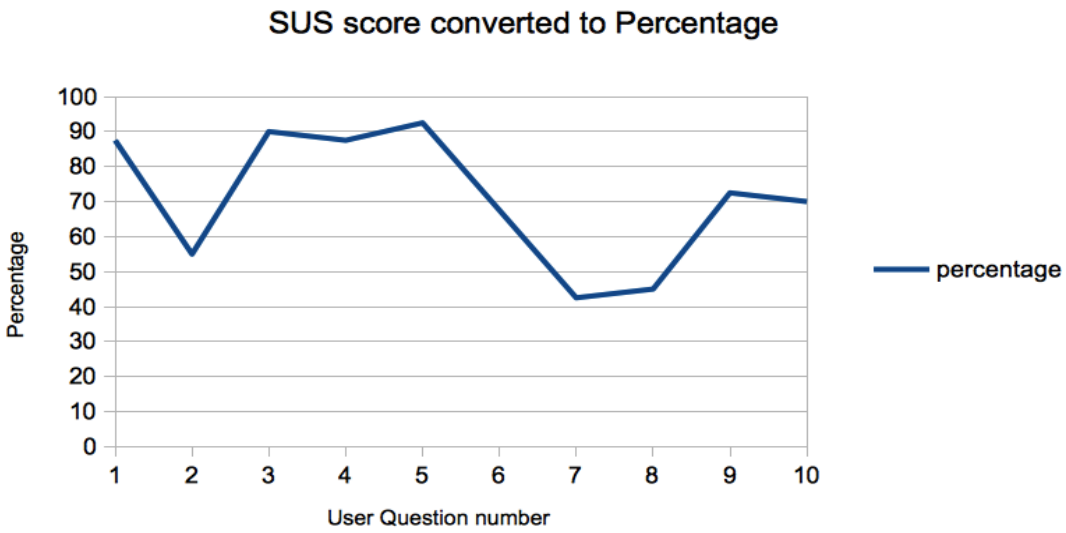


Fig 18: SUS score converted to percentage.

The users generally scored the system highly, the average score is 71%, the highest score is 92.5%, and the lowest is 42.5%. Figure 18 shows that there is high degree of variance between user questionnaire results, this indicates that some users/personas have not been fully catered for, although on taking a holistic view the system provides good functionality.

The three lowest scores coming from user questionnaires 2, 7 & 8, are from users that are aged over 50. This would suggest that they fall into the 'family' persona. Users that fall into the 'family' person, as stipulated by their age, rated the systems the worst this indicates that the family person is the least/worst catered for by the new system.

The three highest scores from the user questionnaires 3,4 & 5 are from users that are aged 24-25, this places them in the 'young person' persona. This indicates that the new system fulfills the needs of both the interaction, and functionality that the 'young person' person requires.

Plotting the average response to each question shows the areas the users liked and disliked about the system. Users responded positively to questions 4 and 10, these questions related to the technical knowledge needed to operate the system, learning curve and support. The lowest score for question 5 is 0, indicating that the users see no improvement at all compared to the currently installed system.

- Question 4 -
  "I think I would need the support of a technical person to be able to use this system."

- Question 10 -
  "I needed to learn a lot of things before I could get going with system"

- Question 5-
  "I found this to be better than the current system I use / systems I have used in the past"

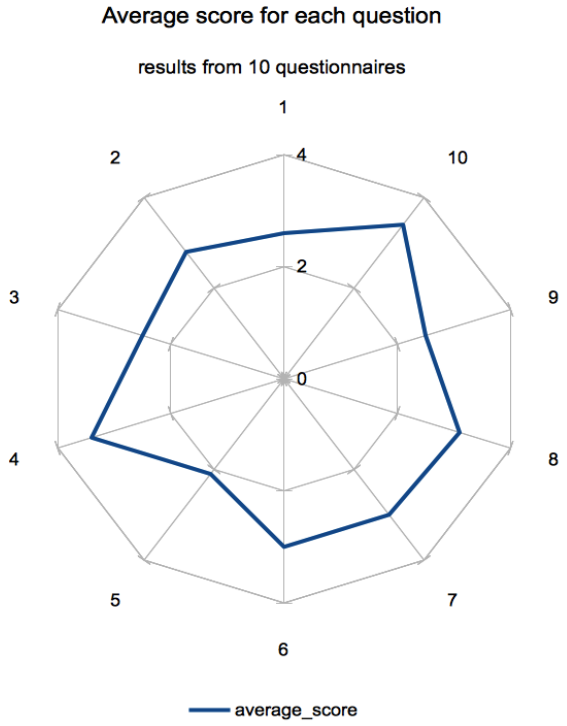


Fig 19: Average score for each question.

Questions 4 & 10 gave the best average score, this shows that the design was successful in reducing the technical challenge that current systems provide. This was a key part of the design for both the hardware and software. The large bezel and large format screens are clear and users immediately know how to operate bezel as it resembles a dial and is familiar across all generations.

This could be due to the design of the system not offering enough options, or flexibility compared to their current system. However this could also be due to users

having finally become accustomed to the currently installed system that due to the unfamiliarity of the new system, they find it too different.

Several users gave feedback relating to the smaller bezel display, 20% of users suggested and would have wanted to the smaller second bezel screen to display the current temperature. This was suggested as visual feedback so the user can see the current temperature and know whether to increase or decrease the temperature and by how much.

Conclusion

Users aged over 50 gave the system the worst score; whilst users aged 24-25 gave the system the best scores. The SUS questionnaire shows that users gave a 71% satisfaction score, which would imply that as a whole the system is well design and implemented.

Most users would not change their current system for this system, studying the users' further comments this is due some key features that are missing in this system when compared to their current system. There were some recurring comments from users, these related to missing functionality compared to their current system or a feature they would want in a new system. The features missing from the system can be summarized in the following user comments:-

- *"Missing advance/ 1 hour boost button"*
- *"No indication if boiler is fired up"*
- *"No way to tell current temperature"*

These comments highlight clear gaps in the system's functionality, as these are responsible for the low score to question 5 adding these features to future prototypes & designs would improve the SUS score for question 5 and the system as a whole.

The average technical ability across the users is deemed to be high; this is validated by the high scores from questions 4 & 10. However all users found the system easy to use, and aesthetically pleasing to look at and use, as shown by user comments:-

- *"Found it easy to use"*
- *"Analogue clock for time selection is nice"*

90% of users rated the bezel and touch screen interface design highly. This implies that the design was successful and that it is an appropriate and efficient implementation. These comments coupled with the positive feedback of the bezel and touchscreen show that the overall system design is good.

The results show that the design is least accommodating to the 'family' user, whereas the 'young' user is shown to be the best accommodated. Using the data and user comments, the 'family' user can be thought of as a 'power user'. They require frequent interaction with the system and have a wide range of function and non-functional requirements, these requirements arise from the users' long term exposure to other heating systems. The 'young person' user will has more simplistic set of

functional and non-functional requirements, as the requirements are not as advanced the design of this heating system better meets the needs of the 'young person' resulting in a higher score.

Review of user comments from questionnaire

Some user comments highlight some faults with the new system; some of these changes can be implemented and would be incorporated into a further/future prototype. However some user comments do not require a change in the system.

User comments that can easily be addressed in future prototypes without compromising the current design, usability of functionality:-

- *"It was not immediately apparent that I had to press "constant" again to turn off the system/program"*
- *"No way to tell current temperature, this is to determine what temperature user should select"*
- *"Missing advance/ 1 hour boost button"*
- *"Unsure if shutdown button turns off the display of switches of the heating system"*
- *"Not obvious if bezel screen display current temperature or set temperature"*
- *"No indication if boiler is fired up"*
- *"In "constant" mode I liked the use of blue/red. [However,] this colour change is not carried through to timer mode"*
- *"In "timed" mode because I can press "TEMPERATURE" any time it felt like I could set a different temperature at the start and end times"*

Some user comments however do not require any changes to the system; this is because either an information box appears on the system screen informing the user, of these errors would only be made once at the time of first use. Therefore as these mistakes/ misunderstanding of feature will have a low frequency and a low impact they will not be addressed.

- *"Preset function not clear, user knew that is how to turn on preset but was unclear if that is where a user would set up the presets."*
- *"Repeat buttons function was not immediately clear, user thought it would repeat the selection with-in the day, not copy to the next day."*

The fact that it was a prototype with very limited functionality meant that some users, by their own admission, felt they could not assess it properly and did not feel confident about the final product.

- *"Because a lot of the features are not implemented on the prototype it's hard to feel confident that it will work as described"*
- *"Because not all the features work fully, I do not feel confident about using this product. This lack of working features also affects my ability to assess this product too"*

Issues with the questionnaire

Some issues with the questionnaire may have given us incomplete or skewed results:

- The 'elderly' persona was not represented in our prototype testing and evaluation questionnaire, ideally we would have an equal weighting of the different user groups. As it stands, we only have a heuristic evaluation of the system with regards to the 'elderly' group.

- Users may have had different interpretations of the question about technical ability.

- Older users were more critical of the system, but this could (at least in part) be due to them being more willing to be critical; the younger users were in our age group and so may have felt more reluctant to provide strong criticism.

- The sample size is very small, so we cannot make very solid conclusions (however, it still allowed us to identify problems we had overlooked).

Additional Notes
All user comments from questionnaire

- *Found it easy to use*
- *It was not immediately apparent that I had to press "constant" again to turn off the system/program*
- *No way to tell current temperature, this is to determine what temperature user should select*
- *Missing advance/ 1 hour boost button*
- *Unsure if shutdown button turns off the display of switches of the heating system*
- *No indication if boiler is fired up*
- *Analogue clock for time selection is nice*
- *not obvious if bezel screen display current temperature or set temperature*
- *Preset function not clear, user knew that is how to turn on preset but was unclear if that is where a user would set up the presets.*
- *Repeat buttons function was not immediately clear, user thought it would repeat the selection with-in the day, not copy to the next day.*
- *"In "constant" mode I liked the use of blue/red. [However,] this colour change is not carried through to timer mode"*
- *"In "timed" mode because I can press "TEMPERATURE" at any time it felt like I could set a different temperature at the start and end times"*
- *because a lot of the features are not implemented on the prototype it's hard to feel confident that it will work as described"*
- *"Because not all the features work fully, [I] do not feel confident about using this product. This lack of working features also affects my ability to assess this product too."*

9: Recommendations

Through the process of design and evaluation of the various prototypes a number of issues were identified that were either never considered important by the design team, were over-looked or could not be implemented for either technical, time or resource limitations. In order for a heating system to be created on these findings a more robust prototype should first be created in order to consider the following weaknesses or problems with the current iteration.

- As stated in the report the system is fairly limited to being useful in individual homes only, it is not suitable for commercial use. There are a number of possibilities to how the final prototype could be extended so to be used in this area including allowing multiple control panels throughout a building all interconnected to allow various areas to be heated on an individual basis.

- The system was ultimately designed to be as user friendly as possible with clear and simple user interfaces. This however limited the functionality of the prototype. The programming features in particular suffered in order to allow a simple design. A future prototype should consider implementing more options for programming the system while still appearing simple in design.

- There was also no consideration made beyond the first prototypes for how a user may interact remotely with the system. This should be considered in the form of some mobile phone connectivity, something that was beyond the scope of this project.

10: Summary

This report aimed to try and redesign and improve upon the typical heating system controls found in households. By analyzing previous, current and future technologies in the field it was possible to draw together some conclusions about what type of system we should create. This lead to three first generation prototypes being designed in a simple, hand drawn fashion that allowed for various elements to be considered and integrated into a single system.

These prototypes provided the base for the project, four varied personas were created in order to evaluate these prototypes and using Nielsen heuristics model each prototype's positives and negatives were evaluated. A summary of these points helped inform a second-generation prototype that was more robustly designed through the use of Photoshop and Flash.

This final prototype was then evaluated again through the use of the created personas but also through some basic user testing.

The goal of this project was to create a heating system control unit that would be better than those currently on the market, this meant improving on simplicity, user interface and learnability while allowing user flexibility to control the system how they wished.

Initially it was felt that the creation of a system that allowed basic functionality but had an array of more complex features that would allow advanced users more flexibility in its use. However after researching the subject it became clear the initial barrier and the most significant barrier for users was the complex design of many of these types of system, Meier (2012). This changed the focus somewhat on what the system should provide, this influenced the design of the initial prototypes but also on the choice of personas. It was felt that most people that used these types of system probably had limited time and patience for learning all the features on a system like this. Therefore it was felt that the focus of the project should change somewhat from an increased technological system to an increased usability focused system. This change in mindset can be seen in the first generation prototypes, while two focused on simple to use interfaces, one concentrated on system options and programmable flexibility.

This change in mindset was not ideal but it was felt that it was early enough in the process that it would not hinder it too much, but it was clear that an early definition of some user requirements would have been very useful in order to guide the process better.

The change in definition of the project also lead to consideration to other areas of the project, because usability became the primary concern it meant that the more technology and business focused persona became less useful for evaluation of the various prototypes created for the project. It became clear that the goals and scenarios posed by this persona would likely not be catered for by the project, meaning that most of the evaluation of the project by this persona would likely be negative. This was identified and addressed in the report but had a clearer definition of what the product was trying to address would have lead to the creation of a more useful persona that may have been able to offer more for the project.

Even with these problems however it was felt that the group identified the scope of the project well and was therefore able to create something that was achievable in the timescale. The second-generation prototype was limited in its capability but it was designed in this manner in order to focus on one area of the system to give a user an indication of a fully working element of the product rather than limited functionality throughout the product.

Overall the group worked well together with members of the group often working together to complete various sections of the project. Google drive was essential to keep a central repository of all the project that all members of the group could work and comment on.

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http://www.amazon.co.uk/product-reviews/B00649IWXI/ref=cm_cr_dp_see_all_btm?ie=UTF8&showViewpoints=1&sortBy=bySubmissionDateDescending

http://www.amazon.com/ecobee-EB-STAT-02-Thermostat-Heat-2-Screen/dp/B004150PJG/ref=cm_cr_pr_product_top#productDetails

http://www.amazon.com/ecobee-EB-STAT-02-Thermostat-Heat-2-Screen/product-reviews/B004150PJG/ref=cm_cr_dp_see_all_summary?ie=UTF8&showViewpoints=1&sortBy=byRankDescending

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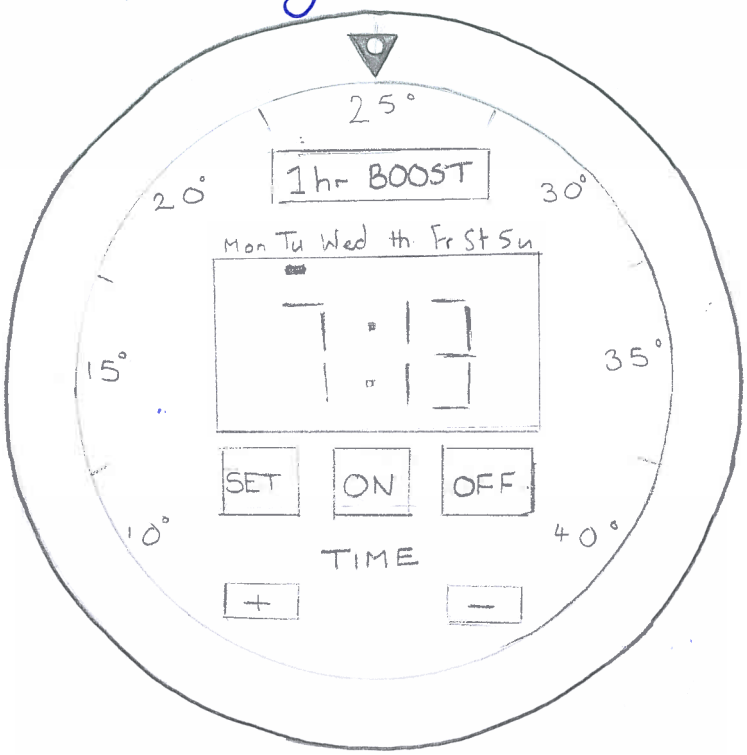
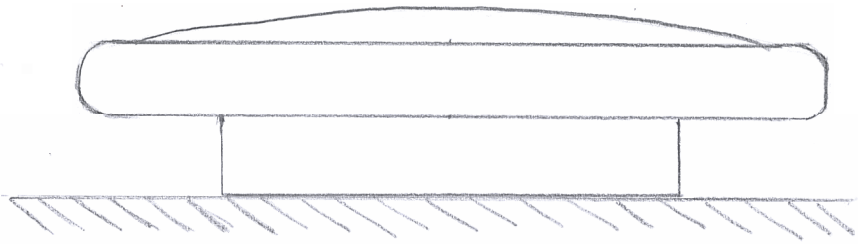
Appendix A:
Circular Prototype

Group 12

Tittle Circular Design	Date 15/02/14



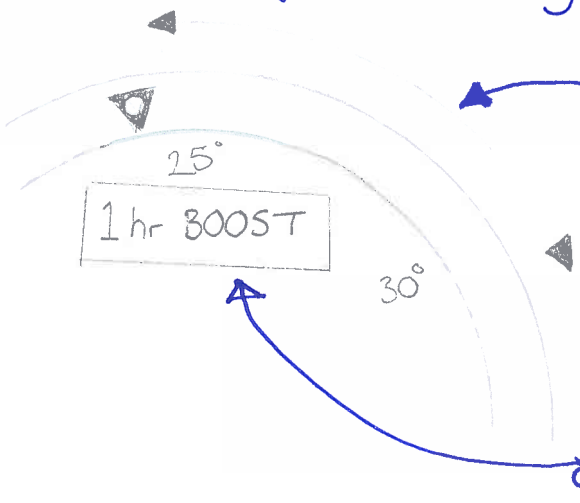


Notes

- Outer ring is made from aluminium and rotates to set temp.
- Each day can be programmed.
- Curved glass face
- 1 hour boost function
- Back lit display for clear viewing
- Buttons are also back-lit

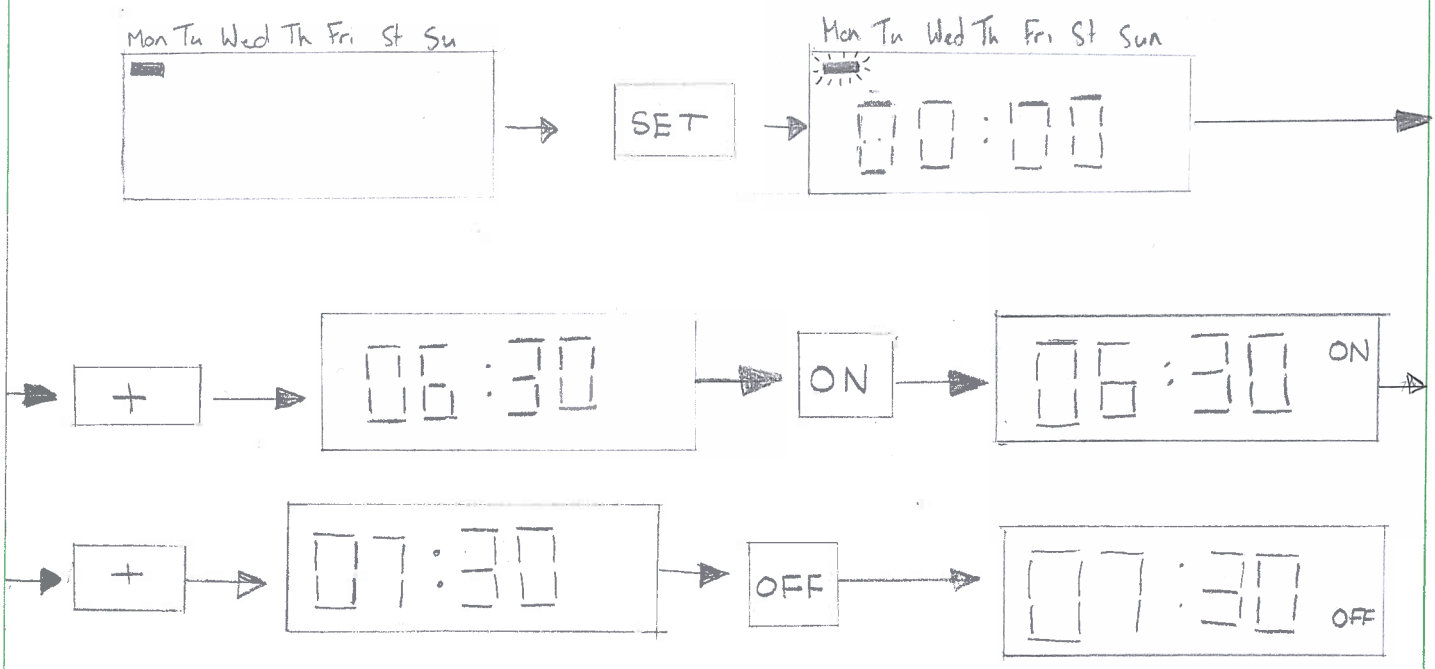
Group 12

Tittle Circular Design - Programming | Date 15/02/14



Twist bezel to change temperature

Heating will come on for 1 hour only



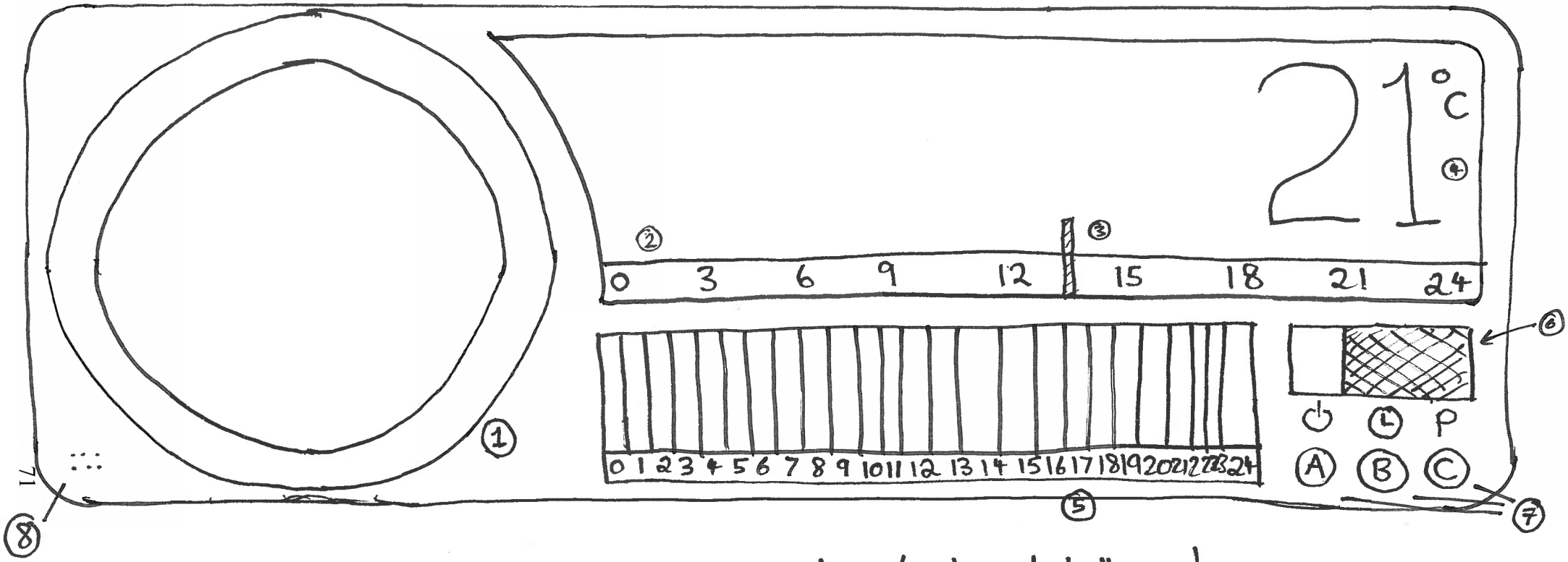
Notes.

1. Press [set] to start programming for Monday.
2. Press [+] till desired time is showing.
3. Press [ON]
4. Press [+] until desired time is showing.
5. Press [OFF].
6. Repeat by pressing [SET] this moves to tuesday

- Heating will come on at 6:30 and go off at 7:30 on Mondays.

Appendix B:
Dial and Buttons Prototype

1st Generation Prototype



① : Twistable Knob. Used to set temperature.

② : 24-hours arranged as a line.

③ : Moving cursor shows current time.

④ : Current Temperature display

⑤ : Push in / push out buttons show 1 hour intervals for setting timed / presets.

⑥ : Switch to choose continuous (⏻), timed (L) and preset (P) modes.

Timed : choose 1 temperature.
Preset : choose multiple temperatures (displayed in back).

⑦ : Buttons to choose presets A, B, or C (hold to set).

⑧ : Speaker for spoken feedback (ie. the temperature is x, You have selected Preset x).

Group 12

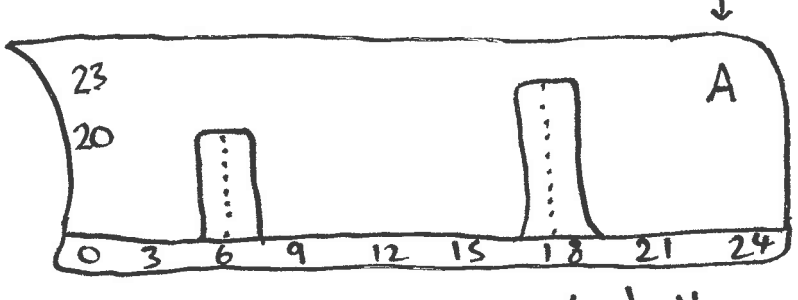
Modes of Operation.

Setting a preset:

1: Hold down button A B or C until the screen displays "SET PRESET x".

2: Push a button in to have the preset turn the heater on in that hour, and turn the knob to that hour's desired temperature. (This will be shown in place of current temperature).

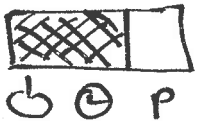
3: The desired preset will be shown on screen as shown (e.g. if user has pressed the 6, 7, 17 & 18 buttons):



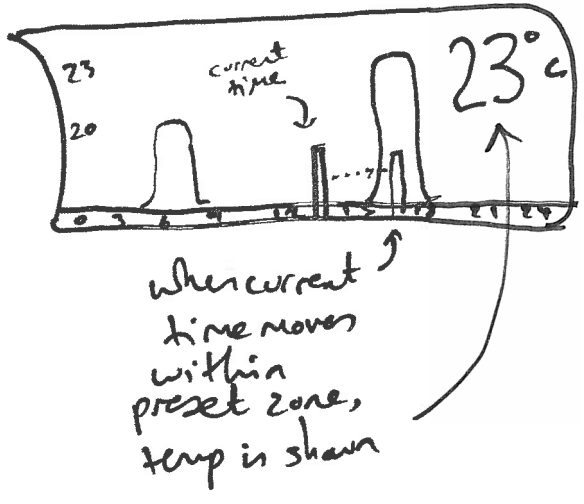
4: User presses the preset button to confirm.

Selecting a preset:

1: User presses A, B or C to use the already defined preset, having moved the switch into 'P' position:



2: The preset appears on screen, and is put into operation:



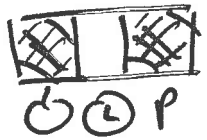
Setting continuous mode:

1: User moves switch to '⏻' position.

2: User manually changes temp. with dial.

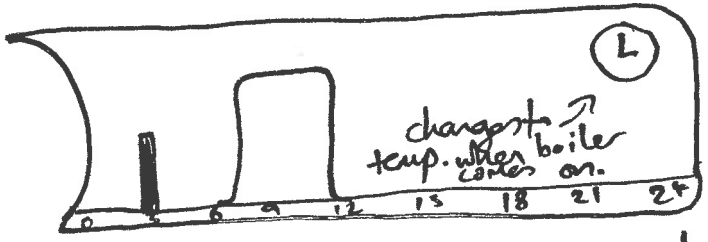
Setting a timed function:

1: User moves switch into 'L' position:



2: User pushes in buttons for hours they want the heating system to turn on.

3: This is displayed on screen:



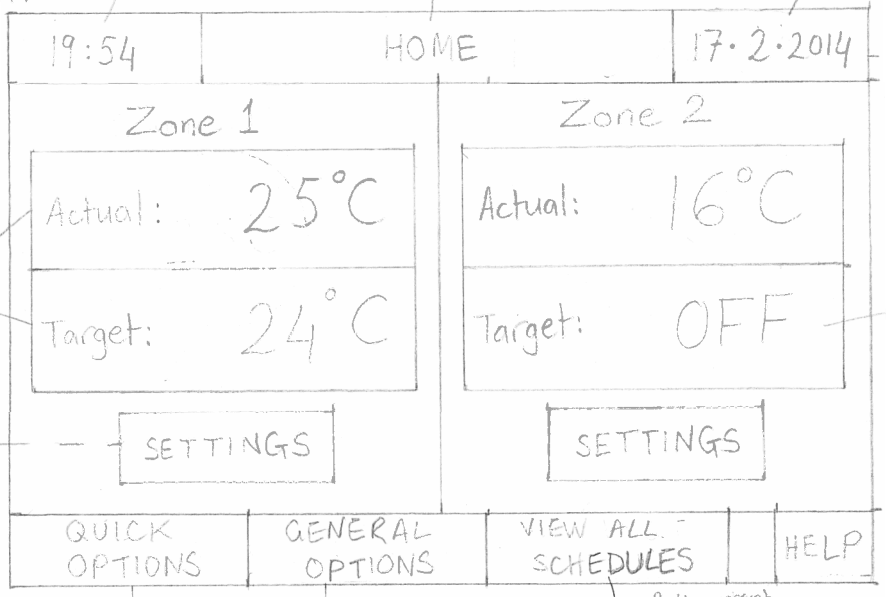
4: User selects desired temperature using knob.

Appendix C:
Touchscreen Prototype

TOUCHSCREEN PROTOTYPE

Group 12

Home screen:



Actual temp. is displayed along with target temp.

Displays if heating is off.

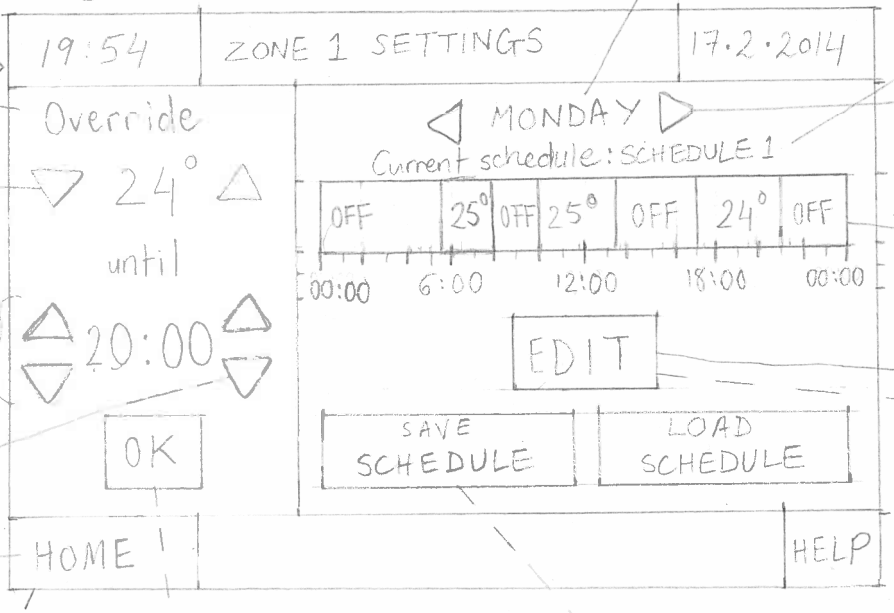
Decreases temp. in all zones by small amount to save energy (include pop-up)

Sets heating to frost protection temp. for set number of days (include pop-up)

User can add their own custom quick options.

can view full current schedules for both zones side-by-side, as well as other saved schedules

Zone 1 settings screen:



Screen initially shows current day

Name of current weekly schedule

Overrides schedule until chosen time

Arrows for changing temp.

Arrows for selecting day

Selected day's schedule

Arrows for changing time

Edit selected day's schedule

10 minute increments

Returns user to home screen

(pop-up)

Any changes to schedule that have not been saved will be lost. Proceed?

YES NO

(pop-up)

Temporarily override current settings?

YES NO

(pop-up)

Save to current weekly schedule or save in new weekly schedule?

CURRENT NEW

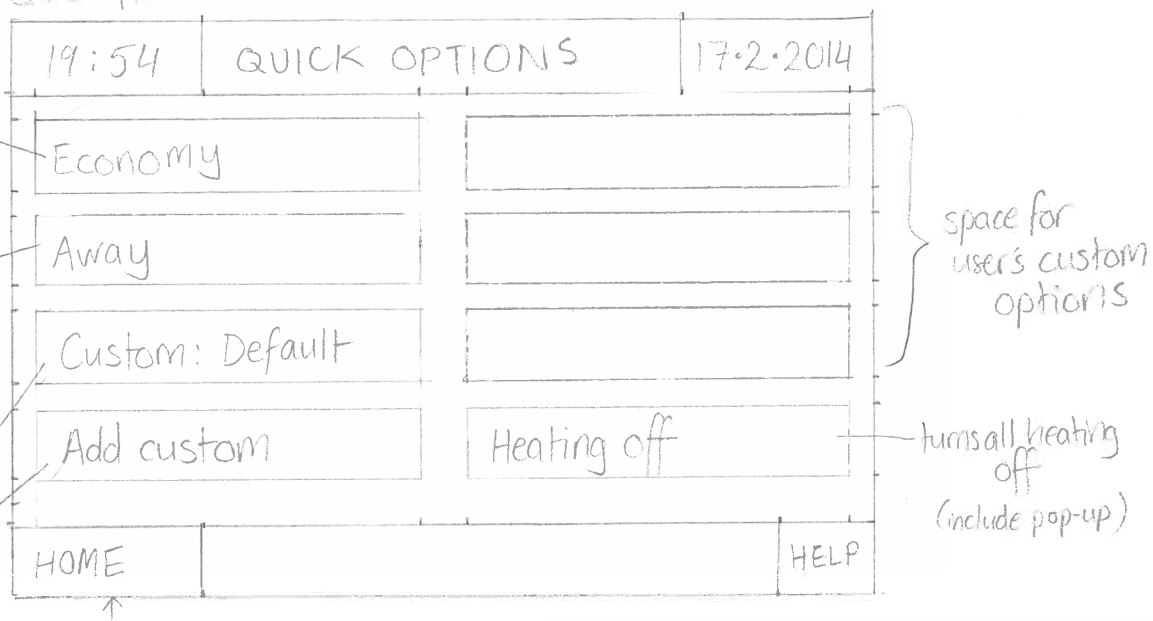
CANCEL

(pop-up)

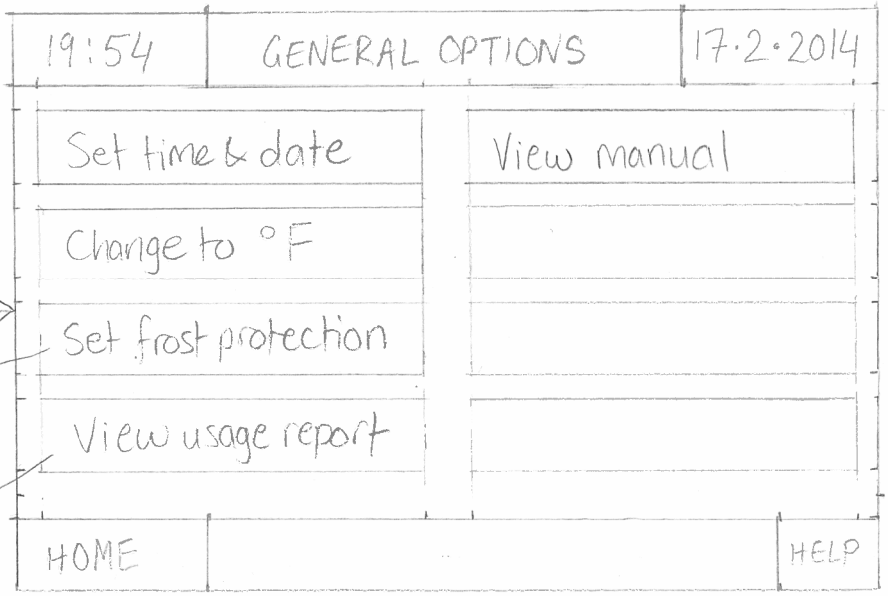
Enter schedule name:

A	B	etc.	
...	...	...	...
1	...	...	OK

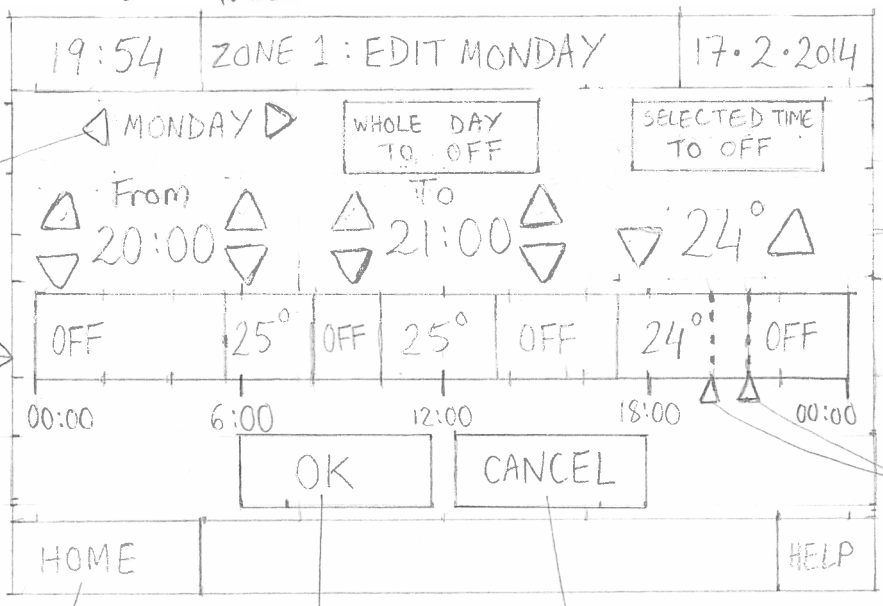
Quick options screen:



General options screen:



Example schedule-editing screen:



Returns to home screen without keeping changes (include pop-up warning - see Zone 1 settings)

Returns to Zone 1 Settings screen with changes intact

Returns to Zone 1 settings screen without keeping changes (include pop-up warning - see Zone 1 settings)

Appendix D: User questionnaire for home heating system interface (second prototype)

Adapted from the System Usability Scale © Digital Equipment Corporation, 1986

For each question, please mark one of the boxes according to how strongly you agree or disagree with that question. If you are unsure of how to answer, please mark the middle box:

	Strongly disagree				Strongly agree
1. I think I would like to use this system frequently					
2. I found the system unnecessarily complex					
3. I thought the system was easy to use					
4. I think I would need the support of a technical person to be able to use this system					
5. I found this to be better than the current system I use / systems I have used in the past					
6. I thought there was too much inconsistency in the system					
7. I would imagine that most people would learn to use this system very quickly					
8. I found the system very cumbersome to use					
9. I felt very confident using the system					

10. I needed to learn a lot of things before I could get going with this system					
	Strongly disagree				Strongly agree
11. I feel the dial makes it easy to change the temperature and time					
12. I would feel comfortable using the touchscreen in real life					

Optional questions:

Age:

Briefly describe your technical ability/experience:

Appendix E: Results from SUS questionnaire

	User questionnaire number										Average Response to each Question
Question No.	1	2	3	4	5	6	7	8	9	10	
1	4	2	3	4	4	2	1	0	3	3	2.6
2	3	2	4	3	4	3	2	1	3	3	2.8
3	3	1	4	3	3	3	1	1	3	3	2.5
4	4	4	4	4	3	4	1	4	3	3	3.4
5	2	1	3	4	4	1	2	0	2	2	2.1
6	4	2	4	4	4	1	3	3	3	2	3
7	3	3	4	2	4	3	1	3	4	3	3
8	4	1	4	4	4	3	2	3	3	3	3.1
9	4	2	3	3	3	3	1	1	2	3	2.5
10	4	4	3	4	4	4	3	2	3	3	3.4
Raw SUS results	35	22	36	35	37	27	17	18	29	28	
SUS as percentage	87.5	55	90	87.5	92.5	67.5	42.5	45	72.5	70	
Ages	25	51	24	24	25	31	53	52	19	23	

Average of raw results	28.4
Average age	32.7
Average total percentage	71

Appendix F: Maya Screenshots

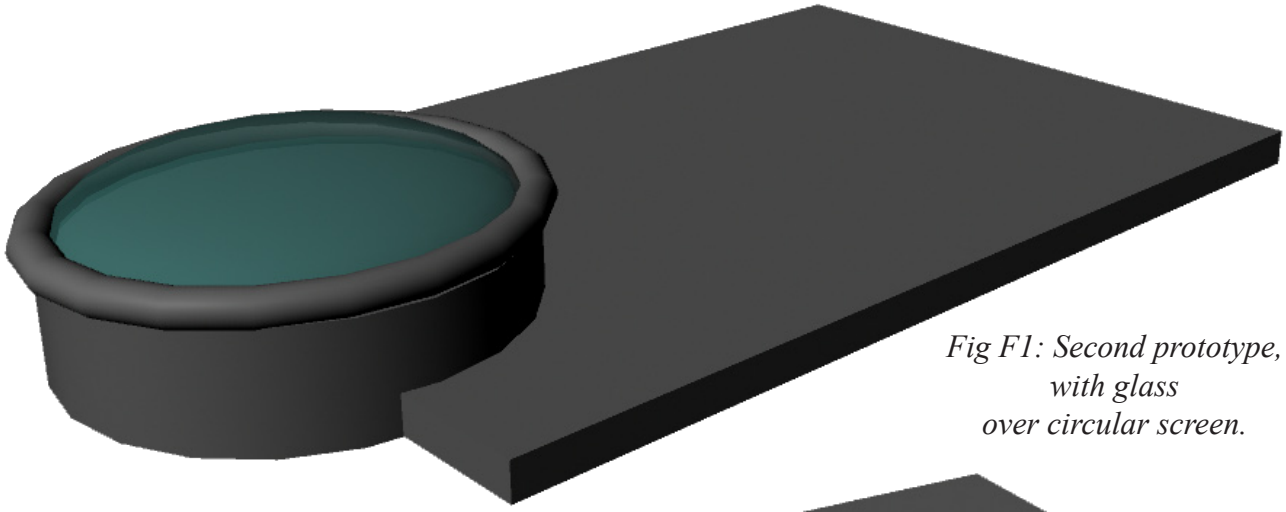


Fig F1: Second prototype, with glass over circular screen.

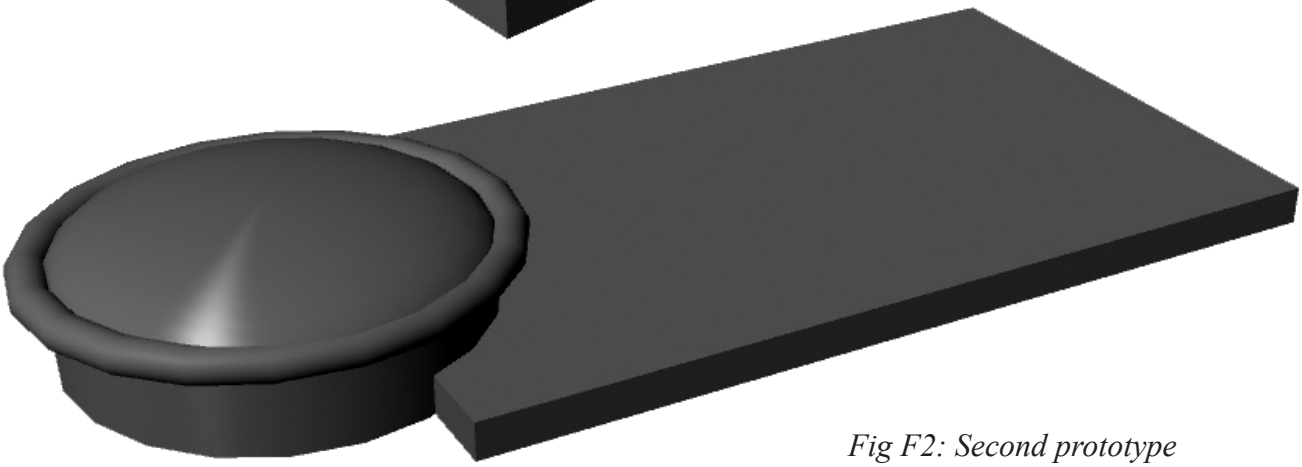


Fig F2: Second prototype from three angles.